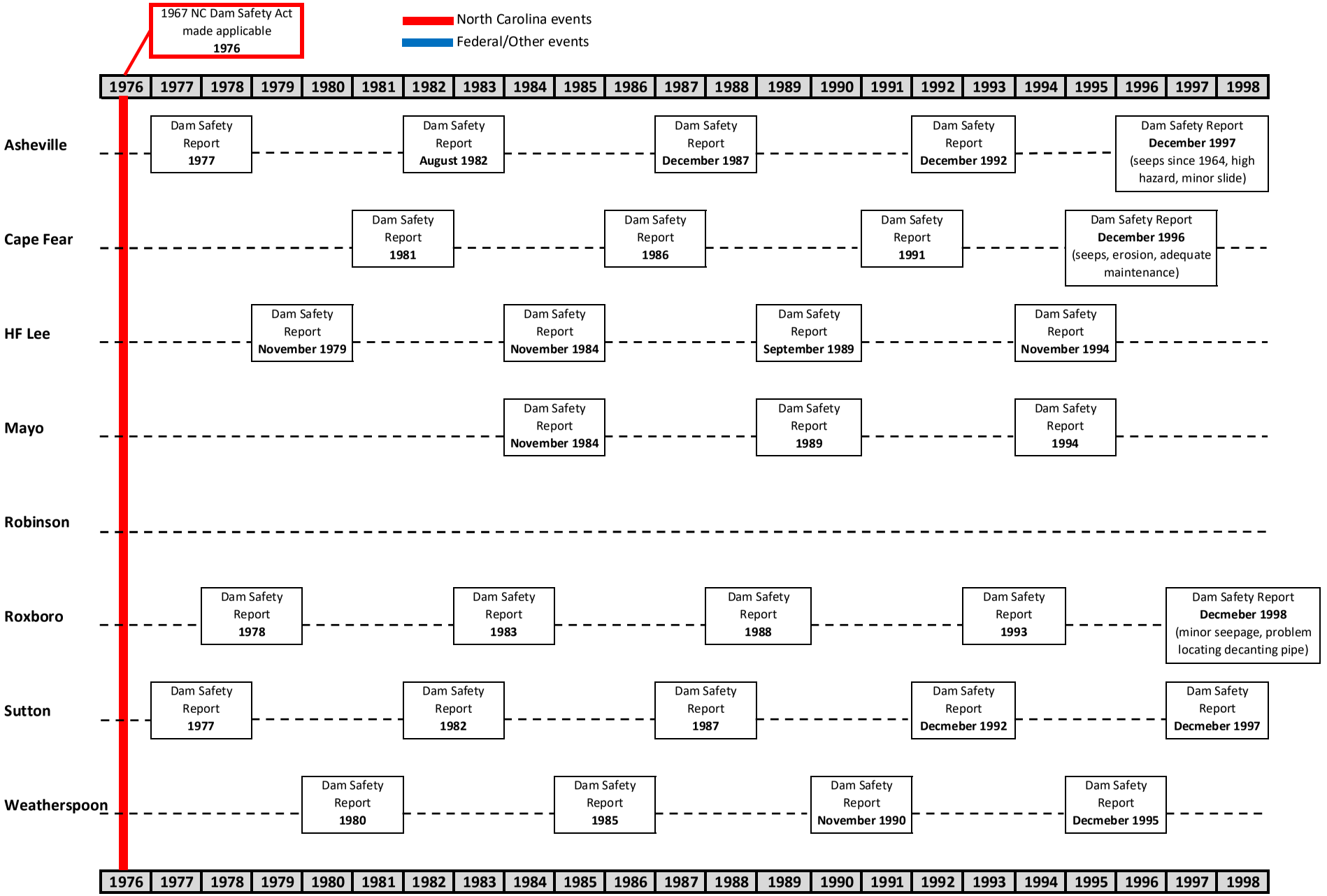
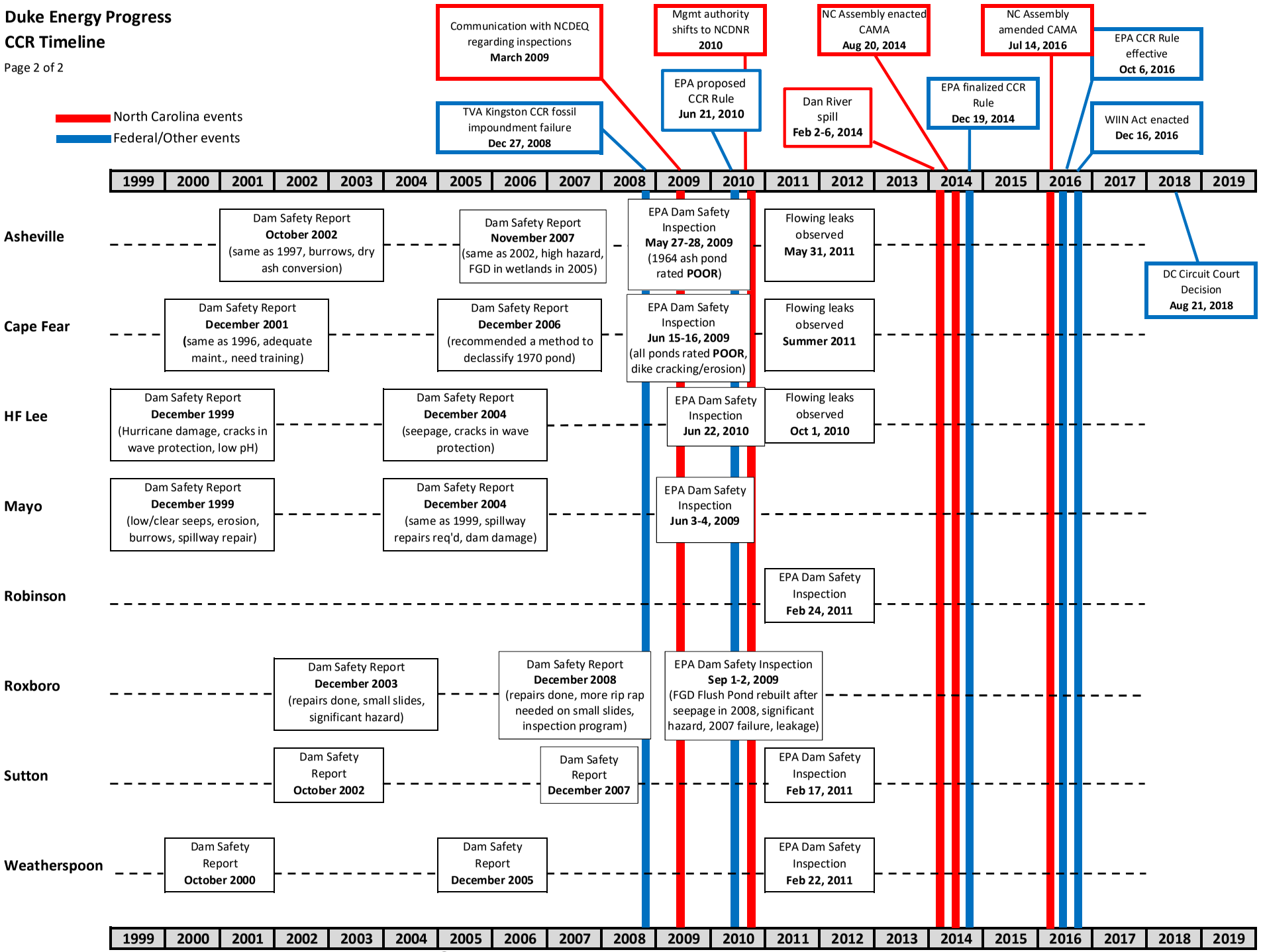
**Duke Energy Progress**
**CCR Timeline**





**Duke Energy Progress**
**CCR Timeline**
Page 2 of 2



# Memorandum

Duke Energy, CCP Closure Engineering

Date: March 22, 2017

To: Mehdi Maibodi

From: Toby Tuttle

Reviewed by: Charlie Smith

Subject: Closure Options Evaluation
Mayo Station
Roxboro, Person County, North Carolina

Duke Energy Progress, (Duke Energy) has reviewed the draft *Closure Options Evaluation* for the ash basin located at Duke Energy's Mayo Station (facility or site), located at 10660 Boston Road, near Roxboro, Person County, North Carolina, prepared by AECOM dated December 22, 2015 with a revised Closure Options Evaluation Worksheet dated February 19, 2016. The draft *Closure Options Evaluation* involved developing ash basin closure strategies and evaluating these options relative to one another. A conceptual-level design for each closure option was developed to provide required inputs to enable this comparison. The evaluation criteria and process defined in the December 2015 draft *Evaluation* were used to rank the closure options and the selected option was advanced to permit-level design.

Since completion of the draft *Closure Options Evaluation*, additional groundwater modeling data and other information has become available. In lieu of revising and finalizing the daft *Evaluation* in its entirety, Duke Energy has reviewed and revised the scoring matrix to include results of groundwater modeling and other information since developed to evaluate potential changes to the proposed closure program. This memorandum presents a summary draft *Evaluation* including an overview of the closure options evaluated, the revised Scoring Table, a discussion of any significant changes in the draft *Evaluation* and Scoring Table included herein, and identifies the most favorable option based on the outcome of the review.

CLOSURE OPTIONS

For the Mayo Station, AECOM in conjunction with Duke Energy developed the following five conceptual closure options for evaluation:

- Option 1: Hybrid Closure
- Option 2: Closure-In-Place
- Option 3A: Closure-By-Removal #1(Existing On-Site Landfill)
- Option 3B: Closure-By-Removal #2 (Existing & New On-Site Landfills)
- Option 4: Closure-By-Removal #3 (Off-Site Third Party Landfill)

Option 1 consists of excavating ash materials from the proposed Closure-by-Removal Areas depicted on Figures B1-1 and B1-2 attached to the draft *Evaluation* and the subsequent placement of these ash materials within the proposed consolidated Hybrid Ash Closure Area.

Following these excavation and placement activities, the Hybrid Ash Closure Area will be capped with an infiltration barrier/cap system meeting the requirements of the Federal CCR Rule and CAMA.

Option 2 consists of leaving the ash material within the Ash Basin, which will be capped with an infiltration barrier/cap system meeting the requirements of the Federal CCR Rule and CAMA.

Option 3A consists of the excavating all ash materials from the proposed Closure-by-Removal Area, and placing these ash materials in a new phase of liner within the Existing On-Site Landfill as depicted in Figure B3 attached to the draft *Evaluation*. This 30-acre phase of the existing landfill will be capped with an infiltration barrier/cap system meeting the requirements of the Federal CCR Rule and CAMA.

Option 3B consists of excavating ash materials from the proposed Closure-by-Removal Area, placing 3 million CY of those ash materials in a new 16-acre phase of liner within the Existing On-Site Landfill, as shown in Figure B3. Once the new Industrial Landfill is permitted and constructed, another 2.5M CY of excavated ash materials from the proposed Closure-by-Removal Area can subsequently be placed within the new Industrial Landfill (which would have a 33-acre footprint). The new phase of the existing landfill and the new Industrial Landfill will be capped with an infiltration barrier/cap system meeting the requirements of the Federal CCR Rule and CAMA.

Option 4 consists of excavating the entire Ash Basin and the disposal of the ash material in an existing, off-site, Class III lined landfill system, assumed to be a 100-mile round trip from Mayo Station.

A more detailed overview of each closure option is presented in the draft *Evaluation.* Also included in the daft Evaluation and not reproduced herein are estimated quantities of ash and soil materials associated with each closure option, figures detailing each option, order of magnitude comparative costs for each option, and other additional information developed to support the comparisons.

## EVALUATION MATRIX

Duke Energy has prepared a scoring matrix to provide consistent evaluation of closure options for each of their various site locations. This scoring evaluation tool is attached and considers the following primary criteria:

- Environmental Protection and Impacts
- Cost
- Schedule
- Regional Factors
- Constructability

Different weights assigned to each criteria. Detailed application of each of these criteria to the selected closure options is presented in the draft *Evaluation*. This includes discussion about project design, permitting, and implementation schedule for the options.

Appendix

Evaluation Criteria and Results

The scoring matrix provided in the attached table, scores each option on a scale of 0 (least favorable) to 10 (most favorable) for each of the specified criteria. The scores for each option are then summed based on specified criterion weighting, resulting in an overall weighted score for each option. The results of the scoring evaluation for the Mayo closure options are summarized in the following table:

| **Criterion** | **Option** | | | | |
|---|---|---|---|---|---|
| | **1** | **2** | **3A** | **3B** | **4** |
| Environmental Protection and Impacts | 2.7 | 2.7 | 2.6 | 2.6 | 2.4 |
| Cost | 2.6 | 2.8 | 2.7 | 2.5 | 0.7 |
| Schedule | 1.0 | 1.5 | 0.2 | 0.0 | 0.2 |
| Regional Factors | 1.4 | 1.4 | 1.1 | 1.0 | 0.2 |
| Constructability | 0.2 | 0.4 | 0.3 | 0.3 | 0.4 |
| **Total Score** | 7.9 | **8.8** | 6.9 | 6.4 | 3.8 |

**CLOSING**

With the changes to the environmental scoring, all of the options final scores rose evenly and did not affect the original ranking order of the options. Based on an evaluation of the criteria established by Duke Energy (environmental protection/impacts, cost, schedule, regional factors and constructability), Option 2, Closure-in-Place, is identified as the most favorable option.

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# Draft Scoring for Evaluation of Closure Options
## Closure Options Evaluation Worksheet
## Ash Basin Closure - Master Programmatic Document
## Duke Energy

**Site Name: Mayo Plant**
**Date: 3/08/17**

| | |
|---|---|
| 1 | = Option-Specific User Input |
| 1 | = Calculated Value |

Placeholder values have been entered in "User Input" cells to prevent division by zero error text in calculated score cells.

| **Threshold Criteria: All closure options must comply with the following threshold criteria based on Duke Energy Guiding Principals for Ash Basin Closure** |
|---|
| 1. Provide continued geotechnical stability meeting appropriate safety factors under applicable loading conditions |
| 2. Provide flow capacity and erosion resistance during design storm and flooding conditions |
| 3. Effectively mitigate groundwater impacts (in conjunction with GW remediation where present) |
| 4. Comply with applicable state and federal regulations (e.g. North Carolina Coal Ash Management Act) |

| Option | Description |
|---|---|
| 1 | Hybrid Closure |
| 2 | Closure In Place |
| 3A | Cosure By Removal: Existing On-site Landfill |
| 3B | Closure By Removal: Existing and New On-site Landfills |
| 4 | Closure By Removal: Third Part Off-site Landfill |

Note: Options that did not meet threshold criteria should be listed in the Options Summary table above for completeness

| **Environmental Protection and Impacts** | **Weight:** | **30%** | | **User Input** | | | | | **Value that Scores** | **Value that Scores** | **Calculated or User Selected Score** | | | | | **Criterion** | **Contribution to** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Criterion** | **Scoring System** | **Required Input** | **Units** | **Option 1** | **Option 2** | **Option 3A** | **Option 3B** | **Option 4** | **10** | **0** | **Option 1** | **Option 2** | **Option 3A** | **Option 3B** | **Option 4** | **Weight** | **Total Score** |
| Modeled surface water impact | Refer to EM Sub-Scoring Sheet | This Area Not Used For Interpretation of Environmental Modeling Results | | | | | | | | | 9 | 9 | 9 | 9 | 9 | 21% | 6.3% |
| Modeled off-site impact | Refer to EM Sub-Scoring Sheet | This Area Not Used For Interpretation of Environmental Modeling Results | | | | | | | | | 10 | 10 | 10 | 10 | 10 | 43% | 12.9% |
| Groundwater impact beyond the waste boundary | Refer to EM Sub-Scoring Sheet | This Area Not Used For Interpretation of Environmental Modeling Results | | | | | | | | | 7.5 | 7.5 | 8 | 8 | 8 | 21% | 6.3% |
| Air emissions off-site (based on miles driven ) | Interpolation. Min value scores 10. Max value scores 0. | Truck miles driven | Miles | 0 | 0 | 2 | 2 | 100 | 0 | 100 | 10 | 10 | 10 | 10 | 0 | 5% | 1.5% |
| Air emissions on-site (based on gallons of fuel consumed) from closure implementation | Interpolation. Min value scores 10. Max value scores 0. | Gallons of fuel consumed | Gallons | 2520000 | 1652000 | 6413000 | 6415000 | 6413000 | 1652000 | 6415000 | 8 | 10 | 0 | 0 | 0 | 5% | 1.5% |
| Avoidance of greenfield disturbance | Interpolation. Min value scores 10. Max value scores 0. | Disturbed acres of greenfield | Acres | 4.5 | 30 | 30 | 49 | 70 | 4.5 | 70 | 10 | 6 | 6 | 3 | 0 | 5% | 1.5% |
| **Weighted Totals (Contribution to Total Score)** | | | | | | | | | | | **2.7** | **2.7** | **2.6** | **2.6** | **2.4** | | |

| **Cost** | **Weight:** | **35%** | | **User Input** | | | | | **Value that Scores** | **Value that Scores** | **Calculated or User Selected Score** | | | | | **Criterion** | **Contribution to** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Criterion** | **Scoring System** | **Required Input** | **Units** | **Option 1** | **Option 2** | **Option 3A** | **Option 3B** | **Option 4** | **10** | **0** | **Option 1** | **Option 2** | **Option 3A** | **Option 3B** | **Option 4** | **Weight** | **Total Score** |
| Closure Cost | Interpolation. Min value scores 10. Max value scores 0. | Closure Cost | USD | $72,000,000 | $36,000,000 | $123,000,000 | $139,000,000 | $621,311,000 | $ 36,000,000.00 | $ 621,311,000.00 | 9.4 | 10.0 | 8.5 | 8.2 | 0.0 | 80% | 28.0% |
| Operation, Maintenance and Monitoring Cost | | OM&M Cost | USD | $4,200,000 | $4,200,000 | $2,900,000 | $3,100,000 | $1,100,000 | $ 1,100,000.00 | $ 4,200,000.00 | 0.0 | 0.0 | 4.2 | 3.5 | 10.0 | 20% | 7.0% |
| **Weighted Totals (Contribution to Total Score)** | | | | | | | | | | | **2.6** | **2.8** | **2.7** | **2.5** | **0.7** | | |

| **Schedule** | **Weight:** | **15%** | | **User Input** | | | | | **Value that Scores** | **Value that Scores** | **Calculated or User Selected Score** | | | | | **Criterion** | **Contribution to** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Criterion** | **Scoring System** | **Required Input** | **Units** | **Option 1** | **Option 2** | **Option 3A** | **Option 3B** | **Option 4** | **10** | **0** | **Option 1** | **Option 2** | **Option 3A** | **Option 3B** | **Option 4** | **Weight** | **Total Score** |
| Initiation Time | Interpolation. Min value scores 10. Max value scores 0. | Time to move first ash | Months | 36 | 30 | 36 | 42 | 36 | 30 | 42 | 5 | 10 | 5 | 0 | 5 | 30% | 4.5% |
| Construction Duration | | Estimated durations | Months | 60 | 48 | 84 | 84 | 84 | 48 | 84 | 7 | 10 | 0 | 0 | 0 | 70% | 10.5% |
| **Weighted Totals (Contribution to Total Score)** | | | | | | | | | | | **1.0** | **1.5** | **0.2** | **0.0** | **0.2** | | |

DRAFT

**Draft Scoring for Evaluation of Closure Options**
**Closure Options Evaluation Worksheet**
**Ash Basin Closure - Master Programmatic Document**
**Duke Energy**

**Site Name: Mayo Plant**
**Date: 3/08/17**

| | |
|---|---|
| 1 | = Option-Specific User Input |
| 1 | = Calculated Value |

Placeholder values have been entered in "User Input" cells to prevent division by zero error text in calculated score cells.

| Regional Factors | Weight: | 15% | | User Input | | | | | Value that Scores | Value that Scores | Calculated or User Selected Score | | | | | Criterion | Contribution to |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Criterion | Scoring System | Required Input | Units | Option 1 | Option 2 | Option 3A | Option 3B | Option 4 | 10 | 0 | Option 1 | Option 2 | Option 3A | Option 3B | Option 4 | Weight | Total Score |
| Plan or potential for beneficial reuse of site | Subjective | Not Used For Subjective Scoring | | | | | | | | | 0 | 0 | 0 | 0 | 0 | 5% | 0.8% |
| Imported soil needs | Interpolation. Min value scores 10. Max value scores 0. | Soil Imported | CY | 0 | 252000 | 370000 | 463000 | 0 | 0 | 463000 | 10 | 5 | 2 | 0 | 10 | 5% | 0.8% |
| Beneficial reuse of CCR | Interpolation. Max value scores 10. Zero value scores 0. | Fraction Used | None | 0.1 | 0.1 | 0 | 0 | 0 | 0.1 | 0 | 10 | 10 | 0 | 0 | 0 | 15% | 2.3% |
| Transportation impact (based on miles driven) | Interpolation. Min value scores 10. Max value scores 0. | Miles Driven | Miles | 0 | 0 | 2 | 2 | 100 | 0 | 100 | 10 | 10 | 10 | 10 | 0 | 65% | 9.8% |
| Noise impact due to on-site activity (based on proximity of neighbors to on-site work areas) | Subjective 0 to 10: 10 is the least noise; 0 is the most noise. | Not Used For Subjective Scoring | | | | | | | | | 7 | 10 | 0 | 0 | 0 | 5% | 0.8% |
| View impact (based on final height of storage facility and land uses within viewshed) | Subjective 0 to 10; 10 is the least visual; 0 is the most visual. | | | | | | | | | | 7 | 9 | 8 | 6 | 10 | 5% | 0.7% |
| **Weighted Totals (Contribution to Total Score)** | | | | | | | | | | | **1.4** | **1.4** | **1.1** | **1.0** | **0.2** | | |

| Constructability | Weight: | 5% | | User Input | | | | | Value that Scores | Value that Scores | Calculated or User Selected Score | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Criterion | Scoring System | Required Input | Units | Option 1 | Option 2 | Option 3A | Option 3B | Option 4 | 10 | 0 | Option 1 | Option 2 | Option 3A | Option 3B | Option 4 | | |
| Consider stormwater management, geotechnical, and dewatering | Subjective 0 to 10: 10 is the least commplicated; 0 is the most complicated | Not Used For Subjective Scoring | | | | | | | | | 3 | 8 | 6 | 5.5 | 7 | 100% | 5.0% |
| **Weighted Totals (Contribution to Total Score)** | | | | | | | | | | | **0.2** | **0.4** | **0.3** | **0.3** | **0.4** | | |
| **Total Score For Each Option (On a Scale of 0 to 10)** | | | | | | | | | | | **7.9** | **8.8** | **6.9** | **6.4** | **3.8** | | |

# DRAFT REPORT

January 8, 2016

Mr. Ken Karably
ABSAT Closure Engineering Manager
Duke Energy
526 South Church Street
Charlotte, North Carolina 28202

RE: **Closure Options Evaluation Summary Report (Draft Rev 0)**
**Ash Basin Closure Plan Development**
**Duke Energy – Roxboro Steam Station**
**Person County, North Carolina**
**Amec Foster Wheeler Project No. 7810-15-0347**

Dear Mr. Karably:

Amec Foster Wheeler Environment & Infrastructure, Inc. (Amec Foster Wheeler) is pleased to submit this Draft Closure Options Evaluation Summary Report Revision 0 (Summary Report) for the Ash Basin Closure Plan Development Project at the Duke Energy Roxboro Steam Station in Person County, North Carolina.

On December 31, 2015, the North Carolina Department of Environmental Quality (NCDEQ) issued "Draft Proposed Impoundment Classifications" under the Coal Ash Management Act (CAMA) for the Roxboro ash basins as follows:

- Roxboro East Ash Basin – Intermediate Risk Classification which requires completion of the closure plan by 12/31/17 and completion of closure by 12/31/24. For this classification, the CCR materials and contaminated soil would have to be removed and disposed of within a landfill.
- Roxboro West Ash Basin – Low Risk Classification which requires completion of the closure plan by 12/31/18 and completion of closure by 12/31/2029. For this classification, the CCR materials can be closed in place with an engineered cap system.

In accordance with CAMA, the NCDEQ is required to make available within 30 days a written declaration that includes the findings of fact that document and support the initial draft classifications. Duke Energy is currently in the process of confirming the classifications with the NCDEQ and has requested Amec Foster Wheeler to hold on further review of closure options for the East Ash Basin pending confirmation. We were further directed to complete the draft closure options evaluation for the West Ash Basin which is covered by this draft report.

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4021 Stirrup Creek Drive, Suite 100
Durham, North Carolina 27703
Tel (919) 381-9900
Fax (919) 381-9901
Licensure: NC Engineering F-1253 amecfw.com

## REPORT ORGANIZATION

This Summary Report presents the results for evaluation of closure options for the Roxboro West Ash Basin and the Roxboro East Ash Basin, respectively, under separate sections. As previously noted, the evaluation of closure options for the East Ash Basin is currently on hold pending confirmation of risk classification with NCDEQ. We have retained descriptive information for the East Ash Basin for reference purposes in this report. The report sections are organized as follows:

### Roxboro West Ash Basin

- Ash Basin Description
- FGD Pond Description
- 2014 Amec Foster Wheeler Landfill Siting Study Overview
- Surface Water Considerations
- Groundwater Considerations
- Environmental Considerations
- Ash Inventory Analysis
- Closure Options Description
- Closure Options Opinion of Probable Cost
- Closure Options Project Schedule Duration
- Closure Options Evaluation Workbook

### Roxboro East Ash Basin (reference information only)

- Ash Basin Description
- East Ash Basin Landfill Storage Capacity Overview
- Surface Water Considerations
- Groundwater Considerations
- Environmental Considerations
- Ash Inventory Analysis
- Closure Options Description (on hold)
- Closure Options Opinion of Probable Cost (on hold)
- Closure Options Project Schedule Duration (on hold)
- Closure Options Evaluation Workbook (on hold)

## ROXBORO WEST ASH BASIN

### West Ash Basin Description

The West Ash Basin Main Dam was constructed in 1973 by Brown & Root across Sargents Creek, which is a tributary to Hyco Lake. The dam is an earth fill embankment with a central low permeability earth core, and a maximum structural height of about 70 feet. In 1986, the dam was raised by 13 feet to the current crest Elevation 470 feet, and the normal pool level is at Elevation 463 feet. The 1986 modifications also included construction of new containment dikes (Ash Basin Dikes No. 1, 2, 3, and 4) and outlet channels. The modifications provided additional storage capacity and changed the internal circulation to increase ash retention/settling time.

The West Ash Basin Dike No. 1 is constructed of rock fill excavated from the nearby outlet channel. The embankment design includes a sand filter blanket on the upstream slope below a layer of rock fill. The crest of the embankment is at Elevation 473 feet and the maximum structural height is approximately 50 feet.

Two discharge outlet structures for the West Ash Basin are located at the West Ash Basin Dike No. 1. Discharge from the West Ash Basin is released into the excavated outlet channel and then flows to Hyco Lake.

From review of available descriptive information, the pond surface area is estimated at around 240 acres, and the contributing drainage area is estimated at 345 acres.

The West Ash Basin Main Dam has a High Hazard classification under the regulations of the North Carolina Department of Environmental Quality (NC DEQ), Land Quality Section, Dam Safety Program.

**Flue Gas Desulfurization (FGD) Pond Description**

The Flue Gas Desulfurization (FGD) Ponds, which are next to the West Ash Basin Main Dam, were constructed on ash deposits within the West Ash Basin area.

Construction of the FGD West Settling Pond and FGD Flush Pond was completed during 2008. Problems with the liner performance led to the shut-down of the ponds and to modifications of the liner design for these ponds. The final construction work was completed in 2011. The FGD East Pond was later constructed because of the problems at the other two ponds.

The FGD West Settling Pond and portions of the FGD Flush Pond containment dikes are constructed of compacted fly ash material. The FGD East Settling Pond dike and portions of the FGD Flush Pond dikes are constructed of compacted soil. The FGD Pond dikes have topsoil on them and are vegetated with grass for erosion protection on the exterior slopes. A liner system is provided on the interior slopes and bottom of each pond area consisting of a geosynthetic clay liner (GCL), and a surface liner of 60-mil-thick, linear-low-density polyethylene (LLDPE). The top of the dike is at Elevation 500 feet (East Settling Pond), and Elevation 506 feet (West Settling and Flush Ponds).

Emergency spillways for each pond cross the dike crests. The FGD Flush Pond emergency spillway at Elevation 503.5 feet releases water into the FGD West Settling Pond, and the FGD West Settling Pond emergency spillway at Elevation 503.0 feet releases water into the FGD East Settling Pond. The emergency spillway for the FGD East Settling Pond is set at Elevation 497.5 feet, and releases water down the exterior dike slope along a concrete revetment onto a riprap energy dissipation blanket. All emergency spillways are shown on design details as being constructed of a 6-inch concrete revetment overlain by the 60-mil, textured LLDPE and underlain by compacted clay. The concrete revetment is a cellular membrane with concrete fill.

Internal drainage features within the FGD East Settling Pond and FGD West Settling Pond consist floating skimmers with “flexible” 24-inch-diameter, high-density polyethylene (HDPE) pipes that connect to 24-inch-diameter HDPE pipes penetrating the dikes. Flow is transferred by the internal drainage features to the bio-reactor wastewater treatment facility located next to the FGD Pond area.

**2015 Amec Foster Wheeler Landfill Siting Study Overview**

On March 25, 2015, Amec Foster Wheeler submitted a report to Duke Energy that includes a high-level evaluation of potential off-site landfill locations within 25 miles of the Roxboro Station. The report also evaluated a proposed on-site landfill site on the west side of the West Ash Basin. The assumed capacity of the proposed landfill was based on ash material volume within the West Ash Basin including the FGD Pond dike estimated at 11,420,000 cubic yards (cy;increased by 10% for Volume Uncertainty Factor).

The criteria used for evaluation of the minimum areas required for landfill options is as follows:

- The landfill will be shaped as a rectangle with a ratio of 2 (length) to 1 (width).
- The maximum developed height of the landfill will be 100 feet.
- The maximum slope will be 3.5 horizontal to 1 vertical.
- A 300-foot buffer will be added to the perimeter of the landfill to account for property boundary offsets.
- Borrow area will be required for a 2-foot-thick cover, 2-foot-thick liner, and 2-foot-thick contingency.
- The maximum depth for borrow will be 10 feet.
- The maximum slope of the borrow area will be 3 horizontal to 1 vertical.
- A 100-foot buffer will be added to the perimeter of the borrow area.

Based on these criteria, the minimum area required for development of an off-site landfill is estimated at 246 acres including 173 acres for the landfill and 73 acres for borrow area. The estimate includes provisions for the buffer area consistent with the criteria. The estimated landfill "footprint" is 103 acres.

The minimum area required for development of an on-site landfill is estimated at 213 acres including 151 acres for the landfill and 62 acres for borrow area. The estimate includes provisions for the buffer area consistent with the criteria. The estimated landfill "footprint" is 86 acres.

The report evaluated five locations for an off-site landfill ranging in distance from 4.0 miles to 14.5 miles from the Roxboro Station. The estimated haul route distance ranged from 7.27 miles to 22.94 miles.

Order-of-magnitude cost estimates were developed for the landfill options, including property acquisition, design, permitting, construction, ash excavation, hauling, placement, and maintenance. For the off-site landfill options, the estimated cost ranged from $155.7 million to $215.5 million. For the on-site landfill option considered, the estimated cost was $137.3 million.

This study report will be considered in developing and evaluating closure options for the West Ash Basin.

**Surface Water Considerations**

Hyco Lake is immediately downstream from the toe of the West Ash Basin Main Dam. The Normal Water Level (NWL) for Hyco Lake is controlled by the primary spillway and is reported to be at

Elevation 410 feet. The 100-year frequency flood stage for Hyco Lake is reported to be at Elevation 413 feet.

The discharge outlet channel for the West Ash Basin begins on the downstream side of West Ash Basin Dike No. 1 and discharges into Hyco Lake for a total developed length of about 2,700 feet. The width of the excavated portion of the discharge channel varies from 20 feet to 85 feet, and the bottom of the channel is at Elevation 445 feet. The water level in the discharge outlet channel is controlled by a weir structure currently set with a crest level at Elevation 446 feet. Water is ponded on the downstream side of Dike No. 1 as a result of the discharge channel water level control. Survey information obtained on January 22, 2015, indicated that the water surface on the downstream side of Dike No. 1 was at Elevation 446.1 feet.

The West Ash Basin water level is currently controlled by the discharge outlet structures, with the NWL reported at Elevation 463 feet. Survey information obtained on January 22, 2015, indicated that the water surface in the remaining ponded area near Dike No. 1 was at Elevation 462.1 feet.

The West Ash Basin is located within the original natural drainage basin formed by Sargents Creek. The original direction of flow was from Dike No. 1 to the Main Dam and Hyco Lake. From review of available project information, the low point for original grade varies from about Elevation 420 feet at Dike No. 1 to about Elevation 390 feet at the Main Dam.

The West Ash Basin currently receives storm water runoff and landfill leachate flow from the East Ash Basin through culvert pipes located under Dunaway Road.

**Groundwater Considerations**

For the West Ash Basin, the SynTerra Comprehensive Site Assessment Report (CSA Report) indicates that saturated ash was encountered at depths ranging from approximately 3 to 7 feet below ground surface (bgs). This corresponds to elevations ranging from 462.84 feet to 464.34 feet. As previously noted, recent survey information indicated that the water surface elevation in the remaining ponded area was at Elevation 462.1 feet.

**Environmental Considerations**

<u>SynTerra Comprehensive Site Assessment (CSA) Report Conclusions</u>

The CSA Report Executive Summary includes the following conclusions:

- No imminent hazard to human health or the environment was identified as a result of groundwater migration from the ash basins.
- Recent groundwater assessment results were consistent with previous results from historical and routine compliance boundary monitoring well data.
- Based on empirical data, no off-site impact to private or public water supply wells was evident.

Review of Environmental Evaluation Criteria

The criteria used for environmental evaluation of closure options is reviewed as follows:

1. Estimated time to achieve compliance with groundwater standards: For Closure by Removal Options, it is assumed that compliance will be achieved at completion of removal for the ash deposits and contaminated residual soil material. For Close in Place/Hybrid Options, it is assumed that compliance may require additional time after completion of closure construction activities for implementation of groundwater remediation corrective actions and/or natural attenuation. The requirements for groundwater corrective action will be confirmed by the groundwater SynTerra Corrective Action Plan which is scheduled to be completed by February 29, 2016. The project schedule duration will be used as the basis for evaluation.
2. Residual groundwater-related risk: (e.g. source removed, source remains above groundwater, source remains below groundwater, conduits remain below ash pond) For Closure by Removal Options, removal of ash material and contaminated residual soil will effectively eliminate the residual groundwater related risk. For Close in Place/Hybrid Options, ash material could remain in place below groundwater level and continue to be a potential source of contamination.
3. Proximity to riverbank or shoreline: Ash material is currently stored in close proximity to Hyco Lake at the WAB Main Dam. In addition, the existing discharge outlet channel carries flow from the WAB to Hyco Lake. For Closure by Removal Options, the WAB Main Dam will be breached and ash material will no longer be stored in close proximity to Hyco Lake. For Close in Place/Hybrid Options, ash material will continue to be stored within the WAB but will be capped with an engineered cover system.
4. Proximity to public drinking water intakes: Based on review of EPA data base, there are no known public water supply systems and intakes located on Hyco Lake or in the vicinity of the Roxboro ash basins. The Hyco River is a tributary stream to the Dan River and is located within the Roanoke River Basin. The closest downstream public water supply intake is believed to be located on the Dan River in South Boston, Virginia. From review of available information, this criteria is not considered to be applicable for evaluation of closure options.
5. Proximity to downgradient public potable water supply well: Public water supply wells were identified by the receptor survey in the CSA Report including a well located at the dry wall plant about 785 feet east of the compliance boundary and two wells located at an elementary school about 2,700 feet west and upgradient from the compliance boundary. For Close in Place/Hybrid Options, ash material will likely remain in place below groundwater level at the site but should not have potential for impacting upgradient public water supply wells.
6. Proximity to private water supply wells: Inventories of of private water supplies wells were compiled as indicated by the CSA Report. Water supply wells are located within 0.5 miles of the site; however these wells are reported to be located upgradient from the Roxboro ash basins. For Close in Place/Hybrid Options, ash material would likely remain in place below groundwater level at the site but would not have potential for impacting upgradient private water supply wells.

7. Proximity to flora, fauna and human receptors: The CSA Report indicates that exposure media for human receptors and ecological receptors includes potentially impacted groundwater, seeps, surface water, soil and sediments. Potential human receptors, current and future, include recreational users and construction/industrial workers and residents. For Closure by Removal Options, ash material would be removed to effectively eliminate the potential exposure media. For Close in Place/Hybrid Options, ash material would remain in place but would be capped with an engineered cover system to effectively contain the exposure media; however, the potential for exposure to impacted groundwater and seeps would remain for ash material that continues to be stored below groundwater level.
8. Restoration of habitat, streams or wetlands: For Closure by Removal Options, site drainage would generally be restored to the condition prior to impoundment of the WAB. For Close in Place/Hybrid Closure Options, restoration of habitat would be provided to the extent of ash removal. For WAB Option 5, the existing ash deposits would be graded and capped with an engineered cover system which represents the minimum potential restoration of habitat.
9. Air emissions off-site: Evaluated based on estimated total miles driven for off-site hauling operations. For Closure by Removal Options with on-site landfill and Hybrid Closure Options, ash hauling and related earthwork operations would be entirely on Duke Energy property (all on-site). Ash hauling would be primarily on off-site public roads for the WAB Closure by Removal Option 2 (with off-site landfill).
10. Air emissions on-site: Evaluated based on estimated total miles driven for on-site hauling operations. For Closure by Removal Options with on-site landfill and Hybrid Closure Options, ash hauling and related earthwork operations will be entirely on Duke Energy property (all on-site). Ash hauling would be primarily on off-site public roads for the WAB Closure by Removal Option 2 (with off-site landfill).
11. Avoidance of greenfield disturbance: This criteria will be evaluated based on the estimated area for potential greenfield disturbance associated with the closure option.

**Ash Inventory Analysis**

The estimates for ash material in storage for the West Ash Basin were obtained from the Amec Foster Wheeler Calculation, Roxboro Steam Station, Estimate of Coal Combustion Residuals (CCR) Quantity, Revision 2A, dated March 23, 2015.

The estimated quantity of ash material within the West Ash Basin including the FGD Pond dikes is reported as follows:

- Estimated Volume – 10,382,000 cubic yards
- Estimated Moist Weight – 12,458,400 tons (based on unit weight of 1.2 tons/cy)

**Closure Options Description**

The proposed closure options were initially identified and reviewed with Duke Energy during a project review meeting on October 21, 2015. The proposed closure options were then reviewed in more detail during a meeting at the Roxboro Station on November 12, 2015.

The proposed closure options covered by this evaluation are identified in Table 1(WAB) – West Ash Basin Closure Options Summary.

Based on conceptual design review, the estimated quantities used for cost estimating are summarized in Table 2(WAB) – West Ash Basin Closure Options Estimated Quantities.

Additional tables were prepared for each closure option under consideration that include the supporting information necessary for option evaluation as follows: Description, Details, Environmental Protection and Impacts, Cost, Schedule, Regional Factors, Constructability, Advantages and Disadvantages. These tables document the details and supporting information for the options that is incorporated in the Closure Options Evaluation Workbook.

The closure options considered for evaluation and tables with supporting information are as follows:

- WAB Closure Option 1 – Closure by Removal Option (with On-site Landfill): The supporting information for evaluation of this option is summarized in Table 3(WAB).
- WAB Closure Option 2 – Closure by Removal Option (with Off-site Landfill): The supporting information for evaluation of this option is summarized in Table 4(WAB).
- WAB Closure Option 3 – Closure by Removal Option (with East Ash Basin Landfill): The supporting information for evaluation of this option is summarized in Table 5(WAB).
- WAB Closure Option 4 – Close in Place Hybrid Closure Option: The supporting information for evaluation of this option are summarized in Table 6(WAB).
- WAB Closure Option 5 – Hybrid Closure Option (with Minimum Excavation/Relocation of Ash): The supporting information for evaluation of this option is summarized in Table 7(WAB).
- WAB Closure Option 6 – Hybrid Closure Option (Combination of Close in Place and Landfill): The supporting information for evaluation of this option is summarized in Table 8(WAB).
- WAB Closure Option A (Not Evaluated) – Hybrid Closure Option (with New Landfill Located within WAB): This closure option assumes all ash material will be removed from the limits of the WAB and permanently disposed in a new landfill within the WAB. During review of closure options on November 12, 2015, Duke Energy directed that this option should not be considered for further evaluation. This direction was given because the Hyco Lake NWL elevation would make it practically impossible to consider placement of a lined landfill area within the West Ash Basin. This closure option is considered to not meet threshold criteria for further evaluation.

**Closure Options Drawings**

Drawings developed to support closure option evaluation are listed as follows:

- Drawing WAB0.1 – (General) WAB Assumed Existing Grade
- Drawing WAB0.2 – (General) WAB Assumed Original Grade
- Drawing WAB1.1 – 2015 Amec Foster Wheeler Landfill Siting Study, On-Site Landfill Option (Figure 7)

- Drawing WAB2.1 – 2015 Amec Foster Wheeler Landfill Siting Study, Landfill Site Study Overview (Figure 1)
- Drawing WAB2.2 - 2015 Amec Foster Wheeler Landfill Siting Study, Person County – Option 1 (Figure 2)
- Drawing WAB3.1 – 2015 Amec Foster Wheeler Landfill Siting Study, On-Site Landfill Option (Figure 7)
- Drawing WAB4.1 – WAB Closure Option 4 Concept Plan
- Drawing WAB4.2 – WAB Closure Option 4 Concept Profiles (Sheet 1 of 2)
- Drawing WAB4.3 – WAB Closure Option 4 Concept Profiles (Sheet 2 of 2)
- Drawing WAB5.1 – WAB Closure Option 5 Concept Plan
- Drawing WAB6.1 – WAB Closure Option 6 Concept Plan

**Closure Options Opinion of Probable Costs**

An Opinion of Probable Cost was developed for each closure option under consideration for evaluation in the Workbook. The cost estimates were generally based on contractor pricing and historical cost data from similar projects. We have also reviewed and incorporated unit costs from from options evaluation for other Amec Foster Wheeler ash basin closure projects.

The opinion of probable cost for the closure options evaluated is summarized as follows:

| Closure Option | Option Description | Total Estimated Cost | Est Post Closure Maint & Monitoring Cost |
|---|---|---|---|
| WAB Option 1 | Closure by Removal (with On-site Landfill) | $160,498,038 | $6,126,000 |
| WAB Option 2 | Closure by Removal (with Off-site Landfill) | $267,468,222 | $6,993,000 |
| WAB Option 3 | Closure by Removal (with EAB Phases 7-9 Landfill) | $169,180,628 | $6,126,000 |
| WAB Option 4 | Close in Place Hybrid Option (CAP Concept) | $95,420,450 | $5,667,000 |
| WAB Option 5 | Close in Place Hybrid Option (Minimum Excavation) | $79,191,749 | $11,226,000 |
| WAB Option 6 | Close in Place Hybrid Option (Combination of Close in Place and Landfill) | $157,553,126 | $9,498,000 |

**Closure Options Project Schedule Duration**

A preliminary assessment of project schedule duration is included in the attached Table 3(WAB) – Table 8(WAB). As part of the schedule assessment, we have performed an analysis of the potential schedule duration for hauling operations associated with each option as indicated by the Schedule Analysis Attachments. The schedule analysis supports the reported estimates for on-site and off-site mileage for hauling operations, number of trucks in the hauling fleet, and potential fuel consumed. It should be noted that Duke Energy provided direction that the maximum volume

of material hauled off-site should be limited to around 1 million cubic yards/year. Duke also advised that the the maximum estimated volume hauled per truckload should be around 17 cubic yards/truck.

The opinion of potential schedule duration for the closure options evaluated is summarized as follows:

| Option | Description | Estimated Duration (Months) | Estimated Duration (Years) | Est Time to Start Ash Removal (Months) |
|---|---|---|---|---|
| WAB Option 1 | Closure by Removal (with On-site Landfill) | 142 | 11.8 | 52 |
| WAB Option 2 | Closure by Removal (with Off-site Landfill) | 228 | 19.0 | 75 |
| WAB Option 3 | Closure by Removal (with EAB Phases 7-9 Landfill) | 142 | 11.8 | 52 |
| WAB Option 4 | Close in Place Hybrid Option (CAP Concept) | 92 | 7.7 | 21 |
| WAB Option 5 | Close in Place Hybrid Option (Minimum Excavation) | 98 | 8.1 | 21 |
| WAB Option 6 | Close in Place Hybrid Option (Combination of Close in Place and Landfill) | 105 | 8.7 | 40 |

**Closure Options Evaluation Workbook**

The Closure Options Evaluation Workbook was developed as a semi-quantitative tool for evaluating the closure options. The tool calculates scores based on a scoring system created using a weighted set of established evaluation categories and criteria. The scoring criteria and weighting system was developed with input from Duke Management with categories and criteria as follows:

1. Environmental Protection and Impacts – 30%
    a. Time to achieve compliance with groundwater standards at compliance boundary
    b. Residual groundwater-related risk (e.g., source removed, source remains above groundwater, source remains below groundwater, conduits remain below ash pond)
    c. Proximity to riverbank or shoreline
    d. Proximity to public drinking water intakes
    e. Proximity to nearest downgradient potable water well
    f. Proximity to flora, fauna and human receptors
    g. Restoration of habitat, streams or wetlands
    h. Air emissions off-site (based on miles driven) from closure implementation
    i. Air emissions on-site (based on miles driver) from closure implementation

   j. Avoidance of greenfield disturbance

2. Cost – 35%
   a. Capital costs
   b. Long-term operations, maintenance, and monitoring costs
3. Schedule – 15%
   a. Initiation time (to begin ash removal or closure activities)
   b. Construction duration
4. Regional Factors – 15%
   a. Planned or potential for beneficial reuse of site
   b. Imported soil needs
   c. CCR beneficial reuse
   d. Transportation impact (based on miles driven)
   e. Noise impact due to on-site activity (based on proximity of neighbors)
   f. Visual impact (based on final height of storage facility, land uses within the view of the developed feature)
5. Constructability – 5%
   a. Subjective and relative comparison of options to one another considering, and not limited to, factors such as dewatering, geotechnical stability, and stormwater management

The information used for inputs into the Workbook for comparison and scoring was developed and documented in the WAB Tables previously identified and attached to this report. The West Ash Basin Closure Evaluation Workbook is also included as an attachment.

## ROXBORO EAST ASH BASIN

As directed by Duke Energy, evaluation of the closure options for the East Ash Basin are on hold pending confirmation of the risk classification. We have included reference information originally prepared to support the evaluation.

### East Ash Basin Description

The East Ash Basin Dam was originally constructed between 1964 and 1965, with a maximum height of about 50 feet. In 1973, the dam was raised 20 feet to its present configuration. The East Ash Basin became inactive following construction of the West Ash Basin around 1986. The East Ash Basin Dam was not included in the Roxboro Phase 2 Reconstitution of Designs investigations and report. The East Ash Basin Dam has a Low Hazard classification under the regulations of the NC DEQ, Land Quality Section, Dam Safety Program.

Beginning about 1988, the East Ash Basin was used as an unlined ash landfill area with the conversion of the plant to dry fly ash handling. About 2001, Phases 1 through 3 of the lined ash monofill area were permitted, which are partially on the unlined fill area. Phases 4 and 5 of the lined monofill area were permitted in 2010, and Phase 6 was permitted in 2013, which is the first phase design with a double liner system and leak detection layer.

### East Ash Basin Landfill Area Storage Capacity Overview

<u>Existing Permitted Phases 1-6</u>

On August 28, 2015, Amec Foster Wheeler submitted a report to Duke Energy presenting the results for the 2014–2015 Landfill Capacity Study for the East Ash Basin Landfill Area. The results for this study are summarized as follows:

- The calculated airspace utilization factor is 2,106 pounds per cubic yard (lb/cy; 1.053 tons/cy).
- The remaining capacity for the currently permitted Phases 1 through 6 landfill was reported to be approximately 1,687,775 cy. This represents the remaining volume of airspace less the 2-foot final cover volume.
- The disposal rate for placement of ash material within the landfill area is estimated in the range of 44,079 to 45,833 tons/month (528,948 to 549,996 tons/year).
- For the utilization factor noted, the estimated annual disposal volume would be in the range of 502,325 to 522,313 cy/year.
- The remaining service life for currently permitted Phases 1 through 6 was estimated in the range of 3.2 to 3.4 years from the April 1, 2015, review date.

<u>Proposed Vertical Expansion of Phases 1-6</u>

On October 23, 2015, Amec Foster Wheeler a preliminary assessment of the potential storage capacity and service life for a vertical expansion of permitted Phases 1 through 6. The vertical expansion is expected to result in a net increase in storage capacity of 1,964,000 cy and result in

3.7 years of additional storage life. This assessment used the landfill airspace utilization factor of 1.05 and disposal rate of 523,810 cy/year.

Proposed Landfill Expansion Phases 7-9

On October 23, 2015, Amec Foster Wheeler provided a preliminary assessment of the potential storage capacity and service life for the proposed expansion of the landfill area with Phases 7 through 9. The Phases 7 through 9 expansion is expected to result in a net increase in storage capacity of 14,000,000 cy and result in 53.5 years of additional storage life. This assessment used the landfill airspace utilization factor of 1.05 and disposal rate of 523,810 cy/year.

As part of this preliminary assessment, the expected time for engineering and design, permitting, and construction required to start filling for the proposed Phase 7 was estimated at about 4.4 years. The expected time required to implement Phases 8 and 9 is expected to be 2.4 years and 2.2 years, respectively.

*(This information should be updated for for closure options evaluation based on more recent landfill expansion planning.)*

Summary of Landfill Storage Capacity Estimates

Based on the available information previously discussed, the estimated storage capacity and storage life for completion of permitted Phases 1 through 6 and proposed expansion options is summarized in the following table:

| Description | Estimated Storage Capacity (cy) | Estimated Storage Life (years)* |
|---|---|---|
| Permitted Phases 1-6 Remaining Capacity | 1,688,000 | 3.2 |
| Phases 1-6 Vertical Expansion | 1,964,000 | 3.7 |
| Phase 7 Expansion | 6,000,000 | 11.5 |
| Phase 8 Expansion | 8,000,000 | 15.3 |
| Phase 9 Expansion | 14,000,000 | 26.7 |
| **Total** | **31,652,000** | **60.4** |

***As previously noted, the estimated storage life is assumed to be from the report date of 4/1/15.

*(This information should be updated for for closure options evaluation based on more recent landfill expansion planning.)*

**Surface Water Considerations**

Hyco Lake is immediately downstream from the toe of the East Ash Basin Dam. The NWL for Hyco Lake is controlled by the primary spillway and is reported to be at Elevation 410 feet. The 100-year frequency flood stage for Hyco Lake is reported to be at Elevation 413 feet.

The original discharge outlet channel for the East Ash Basin begins on the east side of the West Ash Basin, which discharged into Hyco Lake. A pool of standing water is currently on the east side of the current landfill area with the water level at Elevation 467.0 feet (from survey data on May 17, 2014). A review of available design drawingsshows the crest for the original discharge channel control structure at Elevation 464.5 feet. At the time of this report, Amec Foster Wheeler could not determine why the observed water level is higher than the design crest elevation.

The West Ash Basin currently receives storm water runoff and landfill leachate flow from the East Ash Basin through culvert pipes located under Dunaway Road.

**Groundwater Considerations**

For the East Ash Basin, the CSA Report indicates that saturated ash was encountered at depths ranging from 3 to10 feet bgs. This corresponds to elevations ranging from 467.05 to 468.27 feet.

**Environmental Considerations**

The CSA Report Executive Summary includes the following conclusions:

- No imminent hazard to human health or the environment was identified as a result of groundwater migration from the ash basins.
- Recent groundwater assessment results were consistent with previous results from historical and routine compliance boundary monitoring well data.
- Based on empirical data, no off-site impact to private or public water supply wells was evident.

**Ash Inventory Analysis**

The estimates for ash material in storage for the West Ash Basin were obtained from the Amec Foster Wheeler Calculation, Roxboro Steam Station, Estimate of Coal Combustion Residuals (CCR) Quantity, Revision 2A, dated March 23, 2015.

The estimated quantity of ash material within the East Ash Basin is reported in the following table:

| Description | Estimated CCR Volume (cy) | Estimated Moist Unit Weight (ton/cy) | Estimated Moist Weight (tons) |
|---|---|---|---|
| East Ash Basin (original sluiced ash fill) | 5,370,000 | 1.2 | 6,444,000 |
| "Ash Stack" on East Ash Basin | 427,000 | 1.2 | 512,400 |
| Lined Monofill | 5,154,000 | 1.2 | 6,184,800 |
| Unlined Monofill and Subgrade Fill | 6,363,000 | 1.2 | 7,635,600 |
| **TOTAL** | **17,314,000** | | **20,776,800** |

## Closure Options Description

The proposed closure options were initially identified and reviewed with Duke Energy during a project review meeting on October 21, 2015. The proposed closure options were then reviewed in more detail during a meeting at the Roxboro Station on November 12, 2015. The proposed closure options identified for evaluation are listed in Table 1(EAB) – East Ash Basin Closure Options Summary. Consistent with the direction provided by Duke Energy, we have placed further evaluation of these closure options on hold.

## CLOSING

We appreciate the opportunity to provide services for this project. Please do not hesitate to call the Project Manager (Scott Auger) at 919-768-6236 (office) if you have any questions or comments concerning this submittal.

Sincerely,

**Amec Foster Wheeler Environment & Infrastructure, Inc.**

Scott Auger, PE
Project Manager

Ken Daly, PE
Principal Engineer

Nick Parks, PE
Closure Plan Lead Engineer

cc: Distribution to be confirmed by Duke Energy (w/a)

Attachments:

West Ash Basin (WAB) Attachments

- WAB Tables
- WAB Drawings
- WAB Cost Estimates
- WAB Schedule Analysis
- WAB Closure Options Evalaution Workbook

East Ash Basin (EAB) Attachments

- Table 1(EAB) – East Ash Basin Closure Options Summary (evaluation on hold)

Roxboro Closure Options Evaluation
Duke Energy
Amec Foster Wheeler Project No. 7810150347
ATTACHMENTS

West Ash Basin (WAB) Attachments

Roxboro Closure Options Evaluation
Duke Energy
Amec Foster Wheeler Project No. 7810150347
ATTACHMENTS

- WAB Tables

**Amec Foster Wheeler**
**Table 1(WAB) – Closure Option Summary (Identification of Options)**
**Feasibility Analyses - Ash Basin Closure Conceptual Design**
**Roxboro Steam Station West Ash Basin (WAB)**

| Option | Description |
|---|---|
| 1. Closure by Removal Option (with On-site Landfill) | This closure option assumes all ash material will be removed from within the limits of the WAB and permanently disposed of within a new on-site permitted and lined landfill area located on west side of the discharge channel. |
| 2. Closure by Removal Option (with Off-site Landfill) | This closure option assumes all ash material will be removed from within the limits of the WAB and permanently disposed of within a new off-site permitted and lined landfill area. The 2015 Amec Foster Wheeler Landfill Siting Study results will be used as a basis for the requirements for providing an off-site landfill to accommodate the ash material within the WAB. |
| 3. Closure by Removal Option (with East Ash Pond Phases 7-9 Landfill) | This closure option assumes all ash material will be removed from within the limits of the WAB and permanently disposed of in the proposed East Ash Basin Landfill area Phases 7-9. |
| 4. Close in Place Hybrid Option (Partial Removal and Capping) | For this Hybrid Closure Option, ash material is assumed to be consolidated on the northwest side of the pond area in the vicinity of the FGD pond features. The consolidated ash fill will be closed by placement of an engineered cover system. Site drainage will be provided by a constructed/stabilized channel that runs the length of the pond area and discharges into Hyco Lake through a breach in the main dam. For this closure option, WAP Dike No. 1 is assumed to remain in place for diversion of stormwater through the existing discharge outlet channel. |
| 5. Close in Place Hybrid Option (With minimum excavation and relocation of ash) | This closure option represents the approach of minimizing the excavation and relocation of ash material within the WAB. For this option, the existing ash deposits will be graded in the direction of Dike No. 1. Site drainage will be provided by lowering the crest of Dike No. 1 to about Elevation 447 feet. It should be noted that the water level downstream from Dike No. 1 is currently controlled by the weir structure at about Elevation 446 feet. This option will result in requiring a significantly larger surface area for closure with an engineered cover system. For this option, the FGD Pond and Bio-reactor Facilities could possibly remain in service throughout the closure plan implementation. |
| 6. Hybrid Closure Option (Combination of | This option assumes that closure will be accomplished by a combination of Hybrid In-Place Closure and Landfill options. For concept evaluation purposes, we have assumed ash material will be removed from the east side |

**Amec Foster Wheeler**
**Table 1(WAB) – Closure Option Summary (Identification of Options)**
**Feasibility Analyses - Ash Basin Closure Conceptual Design**
**Roxboro Steam Station West Ash Basin (WAB)**

| Option | Description |
|---|---|
| Close In Place and Landfill) | of the WAB to form a stable drainage channel flowing in the direction of the Main Dam (similar to Option 4). The ash material removed will then be relocated to the EAB landfill Phases 7-9. For this option, the FGD Pond and Bio-reactor Facilities could possibly remain in service. All remaining ash fill areas will be closed with an engineered cover system. |
| A. Hybrid Closure Option (with New Landfill Located with WAB)<br><br>NOT EVALUATED | This closure option assumes all ash material will be removed from within the limits of the WAB and permanently disposed of in a new landfill placed within the WAB. During review of closure options November 12, 2015, Duke Energy provided direction that this option should not be considered for further evaluation. This direction was provided in consideration that the Hyco Lake NWL elevation would make it practically impossible to consider placement of a lined landfill area within the West Ash Basin. This closure option is considered to not meet threshold criteria for further evaluation. |

**Table 2(WAB) - Quantity Summary**
**Roxboro Ash Basin Closure Project**
**Ash Basin Closure Options Evaluation**
**Duke Energy - Roxboro Station**
**Roxboro West Ash Basin**
**Prepared By: Scott Auger**
**Draft Rev 0 (1-8-16)**

| | | | | | | | (Moist Weight) | | (Moist Weight) | | (Moist Weight) | | | | Landfill | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Option | Description | Existing Ash Disposal Area (Acres) | In Place Closure Area (Acres) | Estimated Closure Area Soil Cover (CY) | Residual Soil Removal Area (Acres) Note 4 | Ash Removed/ Hauled (CY) | Ash Removed/ Hauled (Tons) Note 1 | Residual Soil Removed (CY) Note 2 | Residual Soil Removed (Tons) Note 3 | Total Ash & Soil Removed/ Hauled (CY) | Total Ash & Soil Removed/ Hauled (tons) | Est Average Total Haul Distance (Miles) | Est Soil Fill Required (CY) | Grading Cut to Fill (CY) | Property Acquistion (Acres) | Landfill Development Area (Acres) | Lined Landfill Area (Acres) | Estimated Landfill Soil Cover (CY) Note 4 | Total Estimated Soil Fill (CY) |
| WAB Option 1 | Closure by Removal (with On-site Landfill) | 186 | 0 | 0 | 186 | 10,382,000 | 12,458,400 | 300,080 | 450,120 | 10,682,080 | 12,908,520 | 1 | | | 0 | 213 | 86 | 277,493 | 277,493 |
| WAB Option 2 | Closure by Removal (with Off-site Landfill) | 186 | 0 | 0 | 186 | 10,382,000 | 12,458,400 | 300,080 | 450,120 | 10,682,080 | 12,908,520 | 15 | | | 400 | 250 | 103 | 332,347 | 332,347 |
| WAB Option 3 | Closure by Removal (with EAB Phases 7-9 Landfill) | 186 | 0 | 0 | 186 | 10,382,000 | 12,458,400 | 300,080 | 450,120 | 10,682,080 | 12,908,520 | 1.2 | | | 0 | 213 | 86 | 277,493 | 277,493 |
| WAB Option 4 | Close in Place Hybrid Option (CAP Concept) | 186 | 77 | 248,453 | 109 | 5,140,645 | 6,168,774 | 175,853 | 263,780 | 5,316,498 | 6,432,554 | 0.5 | 534,519 | | | | | 0 | 782,972 |
| WAB Option 5 | Close in Place Hybrid Option (Minimum excavation) | 186 | 186 | 600,160 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.7 | | 1,314,364 | | | | 0 | 600,160 |
| WAB Option 6 | Close in Place Hybrid Option (Combination of Closue in Place and Landfill) | 186 | 77 | 248,453 | 109 | 5,140,645 | 6,168,774 | 175,853 | 263,780 | 5,316,498 | 6,432,554 | 1.1 | 534,519 | | 0 | 106 | 43 | 138,109 | 921,081 |

DVR Option 6) = 0.50

Notes
1. Assume Moist Unit Weight for ash removed/hauled at 1.2 Tons/CY.
2. Assume Residual Soil removed based on 1 foot average depth.
3. Assume Moist Unit Weight for residual soil removed/hauled at 1.5 Tons/CY.
4. Estimate Closure Area and Landfill Cover Soil at 2 foot depth

Draft Rev. 0 (1-8-16)



# Table 3(WAB) – WAB Option 1
# Closure by Removal Option (with On-site Landfill)
# Summary of Information for Option Evaluation
# Ash Basin Closure Options Evaluation
# Roxboro Station
# Duke Energy

| Subject | Description |
|---|---|
| Description | This closure option assumes all ash material will be removed from within the limits of the WAB and permanently disposed of within a new on-site permitted and lined landfill area located on west side of the discharge channel.<br><br><u>Reference Drawings</u><br><br>• Drawing WAB0.1 – (General) WAB Assumed Existing Grade<br>• Drawing WAB0.2 – (General) WAB Assumed Original Grade<br>• Drawing WAB1.1 – 2015 Amec Foster Wheeler Landfill Siting Study, On-Site Landfill Option (Figure 7) |
| Details | 1. It is assumed that the FGD pond and Bio-reactor facilities will be decommissioned and removed prior to implementation of the proposed closure option. The scope and cost for removal of these facilities is not included with evaluation of this option.<br>2. It is also assumed that storm water inflow will be diverted away from WAB by providing a new discharge outlet for the EAB. The scope and cost for EAB storm water diversion is not included with evaluation of this option.<br>3. Dewatering will initially be required for removal of standing water within the WAB. It is anticipated that dewatering will continue to be necessary throughout the excavation and removal of ash material, removal of contaminated soil, and site restoration. The estimated volume of water to be initially removed is around 162 million gallons.<br>4. Ash material will be excavated from the WAP and disposed of in a new permitted landfill located on the west side of the existing discharge outlet channel. The estimated volume of ash material to be removed and disposed of within the new landfill is around 10,382,000 cy.<br>5. Contaminated residual soil will be removed to an assumed minimum depth of 1 foot and disposed of within the landfill. The estimated volume of soil to be excavated and disposed of for this option is around 300,080 cy.<br>6. The estimated scope, cost and other requirements for development of the on-site landfill will be based on the 2015 Amec Foster Wheeler Landfill Siting Study. For this option, the estimated “footprint” for the lined landfill area will be 86 acres. The total developed area for the landfill including buffers and borrow area development is estimated at 213 acres. It is assumed that no new property acquisition will be required for this option.<br>7. The haul distance between the WAB and the proposed new landfill site is estimated to be about 1 mile.<br>8. The base liner system (bottom to top) is assumed to consist of Geosynthetic Clay Layer (GCL), 60-mil HDPE Geomembrane, Geocomposite Drainage Layer and 2-foot Protective Cover.<br>9. The final cover system (bottom to top) is assumed to consist of a 40-mil double sided textured LLDPE Geomembrane, Geocomposite Drainage Layer, 18-inch final cover soil, and 6-inch vegetative soil cover layer. |

**Table 3(WAB) – WAB Option 1**
**Closure by Removal Option (with On-site Landfill)**
**Summary of Information for Option Evaluation**
**Ash Basin Closure Options Evaluation**
**Roxboro Station**
**Duke Energy**

| Subject | Description |
|---|---|
| | 10. It is assumed that a bridge or embankment with a culvert will be required for crossing the existing outlet channel. The cost for providing the crossing is included with evaluation of this option.<br>11. A comprehensive post-closure site drainage plan will be developed and implemented. It is assumed that site drainage will essentially be restored consistent with site drainage conditions prior to impoundment.<br>12. The WAB Main Dam will be breached as required for jurisdictional decommissioning under NCDEQ Dam Safety and to provide post-closure site drainage. It should be noted that the WAB will be partially flooded after breaching the dam. (Hyco Lake NWL is at Elev 410' and 100 year flood level at Elev 413')<br>13. The WAB Dike No. 1 will be breached as required for jurisdictional decommissioning under NCDEQ Dam Safety and to provide post-closure site drainage. (Note that water level is currently controlled by weir structure with existing crest at Elevation 446'.)<br>14. The existing discharge outlet channel will be drained and ash material removed for the limits of the channel. For estimating purposes, the ash removal cleanup is assumed to include the impoundment area downstream from Dike No. 1 (estimated at 39 acres) and the surface area of the discharge channel (estimated at 6.4 acres. The ash cleanup is estimated based on removal of at least 1 foot of material over the entire area (85,855 cy). The existing structures are also assumed to be removed for closure.<br>15. Permanent surface stabilization measures will be provided for all WAB areas affected by the implementation of this option. The permanent stabilization is expected to primarily consist of seeding and mulching over an estimated area of about 186 acres. .<br>16. The requirements for groundwater monitoring and remediation are not known at the time of this evaluation. The requirements are expected to be confirmed after completion of the SynTerra Groundwater Corrective Action Plan (CAP) Part 2. |
| Environmental Protection and Impacts | 1. Estimated time to achieve compliance with groundwater standards: For Closure by Removal Options, it is assumed that compliance will be achieved at completion of removal for the ash deposits and contaminated residual soil material.<br>2. Residual groundwater-related risk: (e.g. source removed, source remains above groundwater, source remains below groundwater, conduits remain below ash pond) For Closure by Removal Options, removal of ash material and contaminated residual soil will effectively eliminate the groundwater related risk.<br>3. Proximity to riverbank or shoreline: Ash material is currently stored in close proximity to Hyco Lake at the WAB Main Dam. In addition, the existing discharge outlet channel carries flow from the WAB to Hyco Lake. For Closure by Removal Options, the WAB Main Dam will be breached and ash material will no longer be stored in close proximity to Hyco Lake.<br>4. Proximity to public drinking water intakes: Based on review of EPA data base, there are no known public water supply systems and intakes located on Hyco Lake or in the vicinity of the Roxboro ash basins. The Hyco River is a tributary stream to the Dan River and is located within the Roanoke River Basin. The closest downstream public water supply intake is believed to be located on the Dan River in South |

**Table 3(WAB) – WAB Option 1**
**Closure by Removal Option (with On-site Landfill)**
**Summary of Information for Option Evaluation**
**Ash Basin Closure Options Evaluation**
**Roxboro Station**
**Duke Energy**

| Subject | Description |
|---|---|
| | Boston, Virginia. From review of available information, this criteria is not considered to be applicable for evaluation of closure options.<br>5. Proximity to downgradient public potable water supply well: Public water supply wells were identified by the receptor survey in the CSA Report including a well located at the dry wall plant about 785 feet east of the compliance boundary and two wells located at an elementary school about 2,700 feet west and upgradient from the compliance boundary. For Closure by Removal Options, there would be no potential impact on upgradient public water supply wells.<br>6. Proximity to private water supply wells: Inventories of of private water supplies wells were compiled as indicated by the CSA Report. Water supply wells are located within 0.5 miles of the site; however these wells are reported to be located upgradient from the Roxboro ash basins. For Closure by Removal Options, there is no potential impact on upgradient private water supply wells.<br>7. Proximity to flora, fauna and human receptors: The CSA Report indicates that exposure media for human receptors and ecological receptors includes potentially impacted groundwater, seeps, surface water, soil and sediments. Potential human receptors, current and future, include recreational users and construction/industrial workers and residents. For Closure by Removal Options, ash material would be removed to effectively eliminate the potential exposure media.<br>8. Restoration of habitat, streams or wetlands: For Closure by Removal Options, site drainage would generally be restored to the condition prior to impoundment of the WAB.<br>9. Air emissions off-site: Evaluated based on estimated total miles driven for off-site hauling operations. For this closure option, ash hauling and related earthwork operations would be entirely on Duke Energy property (no off-site hauling).<br>10. Air emissions on-site: Evaluated based on estimated total miles driven for on-site hauling operations. For this option, ash hauling and related earthwork operations will be entirely on Duke Energy property. The estimated average vehicle travel distance is around 1.0 miles (one way) and the total estimated miles driven for on-site hauling operations is 1,266,816 miles.<br>11. Avoidance of greenfield disturbance: The estimated area for potential greenfield disturbance associated with the closure option is around 213 acres. |
| Cost | Total Estimated Cost: $160,498,038<br><br>Long Term O&M/Monitoring Cost: $6,126,000 (for 30 years)<br><br>Avoided Cost: The cost for future maintenance and monitoring of the WAB will be avoided; however, maintenance and monitoring of the new on-site landfill area will be required. |

# Table 3(WAB) – WAB Option 1
# Closure by Removal Option (with On-site Landfill)
# Summary of Information for Option Evaluation
# Ash Basin Closure Options Evaluation
# Roxboro Station
# Duke Energy

Schedule

Estimated Project Schedule Duration

The estimated duration for the expected critical path activities is shown in the table below. Based on this schedule analysis, the estimated project duration for this option would be about 11.8 years.

| Activity | Activity Description | Est Activity Duration (Months) | Cum Activity Duration (Months) | Cum Activity Duration (Years) |
|---|---|---|---|---|
| 1.0 | Landfill | | | |
| 1.1 | Preliminary Engineering | 8 | 8 | 0.7 |
| 1.2 | Property Acquisition | 0 | 8 | 0.7 |
| 1.3 | Field Investigation - Finish concurrent with Activity 1.1 | 3 | 8 | 0.7 |
| 1.4 | Permitting | 12 | 20 | 1.7 |
| 1.5 | Construction Documents - Finish concurrent with Activity 1.4 | 6 | 20 | 1.7 |
| 1.6 | Bidding - Start after Activity 1.5 | 3 | 23 | 1.9 |
| 1.7 | Landfill Construction (86 acres) - Start after Activity 1.4 | 29 | 49 | 4.1 |
| 1.8 | Landfill PTO | 3 | 52 | 4.3 |
| 2.0 | Closure Implementation (assumed critical path) | | | |
| 2.1 | Ash and Contaminated Soil Excavation/Hauling | 66 | 118 | 9.8 |
| 2.2 | Site Restoration | 24 | 142 | 11.8 |
| | **Estimated Project Duration** | | **142** | **11.8** |

Initial Time to Begin Ash Removal

For this option, it is assumed that ash removal will not start until completion of the landfill, estimated to be 4.3 years after project start date.

Likelihood of Meeting Regulatory Deadlines

For this review, we have assumed that the closure plan will be completed by 6/1/16 consistent with the current project schedule direction from Duke Energy.

- CAMA High Hazard – Required date for completion of closure is 12/31/19 (about 3.6 years from 6/1/16). It does not appear feasible to meet the regulatory deadline with an estimated project schedule duration of 11.8 years.

**Table 3(WAB) – WAB Option 1**
**Closure by Removal Option (with On-site Landfill)**
**Summary of Information for Option Evaluation**
**Ash Basin Closure Options Evaluation**
**Roxboro Station**
**Duke Energy**

| Subject | Description |
|---|---|
| | • CAMA Intermediate Hazard - Required date for completion of closure is 12/31/24 (about 7.6 years from 6/1/16). It does not appear feasible meeting the regulatory deadline with an estimated project duration of 12 years;<br>• CAMA Low Hazard - Required date for completion of closure is 12/31/29 (about 12.6 years from 6/1/16). It does appear feasible to meet the regulatory deadline with an estimated project duration of 11.8 years. |
| Regional Factors | 1. Beneficial reuse of ash is assumed to continue consistent with current operations.<br>2. Transportation impact (based on miles driven): No off-site impact assumed from vehicle operations.<br>3. Noise impact due to on-site activity (based on proximity of neighbors): On-site noise impact only.<br>4. Visual impact (based on final height of storage facility, land uses within view from the watershed): FGD Pond features to be removed from view. New landfill will be visible from Hyco Lake. |
| Advantages | 1. Complete removal of all ash in the basin and placement within lined landfill.<br>2. No long term environmental monitoring or maintenance required for WAB after ash removal.<br>3. Less miles driven and potentially less air quality impacts than off-site landfill.<br>4. Does not reduce capacity or impact operations for the EAB Landfill.<br>5. WAB restored to original condition prior to impoundment for ash disposal.<br>6. No property acquisition required.<br>7. No impact on other property owners.<br>8. Operation and maintenance remains within the control of the Roxboro Station. |
| Disadvantages | 1. Plans for developing a retention basin in the same area as the proposed on-site landfill.<br>2. Potential cost and uncertainty for permitting new landfill.<br>3. Transmission line corridor and substation in vicinity.<br>4. Added cost for construction and maintenance of bridge or embankment with culvert for crossing the discharge channel.<br>5. Logistics of hauling large quantities of ash material over multi-years schedule.<br>6. WAB would be partially inundated after breaching the Main Dam. |

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**Table 4(WAB) – WAB Option 2**
**Closure by Removal Option (with Off-site Landfill)**
**Summary of Information for Option Evaluation**
**Ash Basin Closure Options Evaluation**
**Roxboro Station**
**Duke Energy**

| Subject | Description |
|---|---|
| Description | This closure option assumes all ash material will be removed from within the limits of the WAB and permanently disposed of within a new off-site permitted and lined landfill area. The 2015 Amec Foster Wheeler Landfill Siting Study results will be used as a basis for the requirements for providing an off-site landfill to accommodate the ash material within the WAB.<br><br><u>Reference Drawings</u><br><br>• Drawing WAB0.1 – (General) WAB Assumed Existing Grade<br>• Drawing WAB0.2 – (General) WAB Assumed Original Grade<br>• Drawing WAB2.1 – 2015 Amec Foster Wheeler Landfill Siting Study, Landfill Site Study Overview (Figure 1)<br>• Drawing WAB2.2 - 2015 Amec Foster Wheeler Landfill Siting Study, Person County – Option 1 (Figure 2) |
| Details | 1. The scope and requirements for ash removal and site restoration will generally be consistent with the details included with Option 1.<br>2. The estimated volume of ash material to be removed and disposed of within the new landfill is around 10,382,000 cy.<br>3. Contaminated residual soil will be removed to an assumed minimum depth of 1 foot and disposed of within the landfill. The estimated volume of soil to be excavated and disposed of for this option is around 300,080 cy.<br>4. The estimated scope, cost and other requirements for development of the off-site landfill will be based on the 2015 Amec Foster Wheeler Landfill Siting Study. The off-site landfill location will be represented by Option 1 as shown on Landfill Site Study Overview, Figures 1 and 2. The estimated “footprint” for the lined landfill area will be 103 acres. The total developed area for the landfill including buffers and borrow area development is estimated at 250 acres. It is assumed that property acquisition will be required for at least 400 acres.<br>5. The haul distance between the WAB and the proposed new landfill site is estimated to be about 15 miles.<br>6. The base liner and final cover system are assumed to be consistent with description provided for Option 1. |
| Environmental Protection and Impacts | 1. Estimated time to achieve compliance with groundwater standards: For Closure by Removal Options, it is assumed that compliance will be achieved at completion of removal for the ash deposits and contaminated residual soil material.<br>2. Residual groundwater-related risk: (e.g. source removed, source remains above groundwater, source remains below groundwater, conduits remain below ash pond) For Closure by Removal Options, removal of ash material and contaminated residual soil will effectively eliminate the residual groundwater related risk.<br>3. Proximity to riverbank or shoreline: Ash material is currently stored in close proximity to Hyco Lake at the WAB Main Dam. In addition, the existing discharge |

**Table 4(WAB) – WAB Option 2**
**Closure by Removal Option (with Off-site Landfill)**
**Summary of Information for Option Evaluation**
**Ash Basin Closure Options Evaluation**
**Roxboro Station**
**Duke Energy**

| Subject | Description |
|---|---|
| | outlet channel carries flow from the WAB to Hyco Lake. For Closure by Removal Options, the WAB Main Dam will be breached and ash material will no longer be stored in close proximity to Hyco Lake.<br>4. Proximity to public drinking water intakes: Based on review of EPA data base, there are no known public water supply systems and intakes located on Hyco Lake or in the vicinity of the Roxboro ash basins. The Hyco River is a tributary stream to the Dan River and is located within the Roanoke River Basin. The closest downstream public water supply intake is believed to be located on the Dan River in South Boston, Virginia. Based on the available information, this criteria should not be considered to be applicable for evaluation of closure options.<br>5. Proximity to downgradient public potable water supply well: Public water supply wells were identified by the receptor survey in the CSA Report including a well located at the dry wall plant about 785 feet east of the compliance boundary and two wells located at an elementary school about 2,700 feet west and upgradient from the compliance boundary. For Closure by Removal Options, there would be no potential impact on upgradient public water supply wells.<br>6. Proximity to private water supply wells: Inventories of of private water supplies wells were compiled as indicated by the CSA Report. Water supply wells are located within 0.5 miles of the site; however these wells are reported to be located upgradient from the Roxboro ash basins. For Closure by Removal Options, there would be no potential impact on upgradient public water supply wells.<br>7. Proximity to flora, fauna and human receptors: The CSA Report indicates that exposure media for human receptors and ecological receptors includes potentially impacted groundwater, seeps, surface water, soil and sediments. Potential human receptors, current and future, include recreational users and construction/industrial workers and residents. For Closure by Removal Options, ash material would be removed to effectively eliminate the potential exposure media.<br>8. Restoration of habitat, streams or wetlands: For Closure by Removal Options, site drainage would generally be restored to the condition prior to impoundment of the WAB.<br>9. Air emissions off-site: Evaluated based on estimated total miles driven for off-site hauling operations. For this option, the estimated average vehicle travel distance is estimated at 1 mile on-site and 14 miles off-site for hauling operations for total of 15 miles (one way). The total estimated miles driven for off-site hauling operations is 7,934,268 miles.<br>10. Air emissions on-site: Evaluated based on estimated total miles driven for on-site hauling operations. For this option, the estimated average vehicle travel distance is around 1 mile on-site and 14 miles off-site for hauling operations, for a total of 15 miles (one way). The total estimated miles driven for on-site hauling operations is 1,266,816 miles. .<br>11. Avoidance of greenfield disturbance: The estimated area for potential greenfield disturbance associated with the closure option is around 250 acres. |
| Cost | Total Estimated Cost: $267,468,222 |

## Table 4(WAB) – WAB Option 2
## Closure by Removal Option (with Off-site Landfill)
## Summary of Information for Option Evaluation
## Ash Basin Closure Options Evaluation
## Roxboro Station
## Duke Energy

| Subject | Description |
|---|---|
| | Long Term O&M/Monitoring Cost: $6,993,000 (for 30 years)<br><br>Avoided Cost: The cost for future maintenance and monitoring of the WAB will be avoided; however, maintenance and monitoring of the new on-site landfill area will be required. |

# Table 4(WAB) – WAB Option 2
# Closure by Removal Option (with Off-site Landfill)
# Summary of Information for Option Evaluation
# Ash Basin Closure Options Evaluation
# Roxboro Station
# Duke Energy

Schedule

Estimated Project Schedule Duration

The estimated duration for the expected critical path activities is shown in the table below. Based on this schedule analysis, the estimated project duration for this option would be about 19 years. As requested by Duke Energy, the assumed maximum haul rate for off-site landfill disposal operations is around 1 million cubic yards/year.

| Activity | Activity Description | Est Activity Duration (Months) | Cum Duration (Months) | Cum Duration (Years) |
|---|---|---|---|---|
| 1.0 | Landfill | | | |
| 1.1 | Preliminary Engineering | 8 | 8 | 0.7 |
| 1.2 | Property Acquisition | 12 | 20 | 1.7 |
| 1.3 | Field Investigation | 3 | 23 | 1.9 |
| 1.4 | Permitting | 12 | 35 | 2.9 |
| 1.5 | Construction Documents - Finish concurrent with Activity 1.4 | 6 | 35 | 2.9 |
| 1.6 | Bidding | 3 | 38 | 3.2 |
| 1.7 | Landfill Construction (103 acres) | 34 | 72 | 6.0 |
| 1.8 | Landfill PTO | 3 | 75 | 6.3 |
| 2.0 | Closure Implementation (assumed critical path) | | | |
| 2.1 | Ash and Contaminated Soil Excavation/Hauling (assuming maximum haul rate of around 1 million cy/year per Duke direction) | 128 | 204 | 17.0 |
| 2.2 | Site Restoration | 24 | 228 | 19.0 |
| | **Estimated Project Duration** | | **228** | **19.0** |

Initial Time to Begin Ash Removal

For this option, it is assumed that ash removal will not start until completion of the landfill, estimated to be 6.3 years after project start date.

Likelihood of Meeting Regulatory Deadlines

For this review, we have assumed that the closure plan will be completed by 6/1/16 consistent with the current project schedule direction from Duke Energy.

- CAMA High Hazard – Required date for completion of closure is 12/31/19 (about 3.6 years from 6/1/16). It does not appear feasible to meet the regulatory deadline with an estimated project schedule duration of 19 years.

**Table 4(WAB) – WAB Option 2**
**Closure by Removal Option (with Off-site Landfill)**
**Summary of Information for Option Evaluation**
**Ash Basin Closure Options Evaluation**
**Roxboro Station**
**Duke Energy**

| Subject | Description |
|---|---|
| | • CAMA Intermediate Hazard - Required date for completion of closure is 12/31/24 (about 7.6 years from 6/1/16). It does not appear feasible meeting the regulatory deadline with an estimated project duration of 19 years;<br>• CAMA Low Hazard - Required date for completion of closure is 12/31/29 (about 12.6 years from 6/1/16). It does appear feasible to meet the regulatory deadline with an estimated project duration of 19 years. |
| Regional Factors | 1. Beneficial reuse of ash is assumed to continue consistent with current operations.<br>2. Transportation impact (based on miles driven): Significant off-site impact from vehicle operations.<br>3. Noise impact due to on-site activity (based on proximity of neighbors): On-site noise impact only with exception of frequent heavy vehicle operations over public roads.<br>4. Visual impact (based on final height of storage facility, land uses within view from the watershed): FGD Pond features to be removed from view. New landfill will likely be visible to public. |
| Advantages | 1. Complete removal of all ash in the basin and placement within lined landfill.<br>2. No long term environmental monitoring or maintenance required for WAB after ash removal.<br>3. Does not reduce capacity or impact operations for the EAB Landfill.<br>4. WAB restored to original condition prior to impoundment for ash disposal. |
| Disadvantages | 1. Cost and uncertainty for permitting new landfill.<br>2. Cost and uncertainty over obtaining suitable property for development of new off-site landfill.<br>3. Impact on public from vehicle operations including noise, traffic congestion, and increased risk for vehicle accidents.<br>4. Damage to public roads and bridges from hauling operations..<br>5. Logistics of hauling large quantities of ash material over multi-years schedule.<br>6. WAB would be partially inundated after breaching the Main Dam. |

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# Table 5(WAB) – WAB Option 3
# Closure by Removal Option (with East Ash Pond Phases 7-9 Landfill)
# Summary of Information for Option Evaluation
# Ash Basin Closure Options Evaluation
# Roxboro Station
# Duke Energy

| Subject | Description |
|---|---|
| Description | This closure option assumes all ash material will be removed from within the limits of the WAB and permanently disposed of in the proposed East Ash Basin Landfill area Phases 7-9.<br><br><u>Reference Drawings</u><br><br>• Drawing WAB0.1 – (General) WAB Assumed Existing Grade<br>• Drawing WAB0.2 – (General) WAB Assumed Original Grade<br>• Drawing WAB3.1 – 2015 Amec Foster Wheeler Landfill Siting Study, On-Site Landfill Option (Figure 7) |
| Details | 1. The scope and requirements for ash removal and site restoration will generally be consistent with the details included with Option 1.<br>2. The estimated volume of ash material to be removed and disposed of within the new landfill is around 10,382,000 cy.<br>3. Contaminated residual soil will be removed to an assumed minimum depth of 1 foot and disposed of within the landfill. The estimated volume of soil to be excavated and disposed of for this option is around 300,080 cy.<br>4. The estimated scope, cost and other requirements for development of the on-site landfill will be based on the 2015 Amec Foster Wheeler Landfill Siting Study. It is assumed that a portion of the proposed landfill development for EAB Landfill Phases 7-9 would be utilized for disposal of ash material excavated for the WAB closure. For this option, the estimated "footprint" for the lined landfill area will be 86 acres. The total developed area for the landfill including buffers and borrow area development is estimated at 213 acres. It is assumed that no new property acquisition will be required for this option. .<br>5. The haul distance between the WAB and the proposed new landfill site is estimated to be about 1.2 miles.<br>6. The base liner and final cover system are assumed to be consistent with description provided for Option 1 |
| Environmental Protection and Impacts | 1. Estimated time to achieve compliance with groundwater standards: For Closure by Removal Options, it is assumed that compliance will be achieved at completion of removal for the ash deposits and contaminated residual soil material.<br>2. Residual groundwater-related risk: (e.g. source removed, source remains above groundwater, source remains below groundwater, conduits remain below ash pond) For Closure by Removal Options, removal of ash material and contaminated residual soil will effectively eliminate the groundwater related risk.<br>3. Proximity to riverbank or shoreline: Ash material is currently stored in close proximity to Hyco Lake at the WAB Main Dam. In addition, the existing discharge outlet channel carries flow from the WAB to Hyco Lake. For Closure by Removal Options, the WAB Main Dam will be breached and ash material will no longer be stored in close proximity to Hyco Lake. |

**Table 5(WAB) – WAB Option 3**
**Closure by Removal Option (with East Ash Pond Phases 7-9 Landfill)**
**Summary of Information for Option Evaluation**
**Ash Basin Closure Options Evaluation**
**Roxboro Station**
**Duke Energy**

| Subject | Description |
|---|---|
| | 4. Proximity to public drinking water intakes: Based on review of EPA data base, there are no known public water supply systems and intakes located on Hyco Lake or in the vicinity of the Roxboro ash basins. The Hyco River is a tributary stream to the Dan River and is located within the Roanoke River Basin. The closest downstream public water supply intake is believed to be located on the Dan River in South Boston, Virginia. From review available information, this criteria is not considered to be applicable for evaluation of closure options.<br>5. Proximity to downgradient public potable water supply well: Public water supply wells were identified by the receptor survey in the CSA Report including a well located at the dry wall plant about 785 feet east of the compliance boundary and two wells located at an elementary school about 2,700 feet west and upgradient from the compliance boundary. For Closure by Removal Options, there would be no potential impact on upgradient public water supply wells.<br>6. Proximity to private water supply wells: Inventories of of private water supplies wells were compiled as indicated by the CSA Report. Water supply wells are located within 0.5 miles of the site; however these wells are reported to be located upgradient from the Roxboro ash basins. For Closure by Removal Options, there is no potential impact on upgradient private water supply wells.<br>7. Proximity to flora, fauna and human receptors: The CSA Report indicates that exposure media for human receptors and ecological receptors includes potentially impacted groundwater, seeps, surface water, soil and sediments. Potential human receptors, current and future, include recreational users and construction/industrial workers and residents. For Closure by Removal Options, ash material would be removed to effectively eliminate the potential exposure media.<br>8. Restoration of habitat, streams or wetlands: For Closure by Removal Options, site drainage would generally be restored to the condition prior to impoundment of the WAB.<br>9. Air emissions off-site: Evaluated based on estimated total miles driven for off-site hauling operations. For this closure option, ash hauling and related earthwork operations would be entirely on Duke Energy property (no off-site hauling).<br>10. Air emissions on-site: Evaluated based on estimated total miles driven for on-site hauling operations. For this option, ash hauling and related earthwork operations will be entirely on Duke Energy property. The estimated average vehicle travel distance for hauling operations is around 1.2 miles (one way). The total estimated miles driven for on-site hauling operations is 1,520,179 miles.<br>11. Avoidance of greenfield disturbance: The estimated area for potential greenfield disturbance associated with the closure option is around 213 acres. |
| Cost | Total Estimated Cost: $169,180,628<br><br>Long Term O&M/Monitoring Cost: $6,126,000 (for 30 years)<br><br>Avoided Cost: The cost for future maintenance and monitoring of the WAB will be avoided; however, maintenance and monitoring of the new off-site landfill area will be required. |

# Table 5(WAB) – WAB Option 3
# Closure by Removal Option (with East Ash Pond Phases 7-9 Landfill)
# Summary of Information for Option Evaluation
# Ash Basin Closure Options Evaluation
# Roxboro Station
# Duke Energy

Schedule

Estimated Project Schedule Duration

The estimated duration for the expected critical path activities is shown in the table below. Based on this schedule analysis, the estimated project duration for this option would be about 11.8 years.

| Activity | Activity Description | Est Activity Duration (Months) | Cum Duration (Months) | Cum Duration (Years) |
|---|---|---|---|---|
| 1.0 | Landfill | | | |
| 1.1 | Preliminary Engineering | 8 | 8 | 0.7 |
| 1.2 | Property Acquisition | 0 | 8 | 0.7 |
| 1.3 | Field Investigation - Finish concurrent with Activity 1.1 | 3 | 8 | 0.7 |
| 1.4 | Permitting | 12 | 20 | 1.7 |
| 1.5 | Construction Documents - Finish concurrent with Activity 1.4 | 6 | 20 | 1.7 |
| 1.6 | Bidding - Start after Activity 1.5 | 3 | 23 | 1.9 |
| 1.7 | Landfill Construction (86 acres) - Start after Activity 1.4 | 29 | 49 | 4.1 |
| 1.8 | Landfill PTO | 3 | 52 | 4.3 |
| 2.0 | Closure Implementation (assumed critical path) | | | |
| 2.1 | Ash and Contaminated Soil Excavation/Hauling | 66 | 118 | 9.8 |
| 2.2 | Site Restoration | 24 | 142 | 11.8 |
| | **Estimated Project Duration** | | **142** | **11.8** |

Initial Time to Begin Ash Removal

For this option, it is assumed that ash removal will not start until completion of the landfill, estimated to be 4.3 years after project start date.

Likelihood of Meeting Regulatory Deadlines

For this review, we have assumed that the closure plan will be completed by 6/1/16 consistent with the current project schedule direction from Duke Energy.

- CAMA High Hazard – Required date for completion of closure is 12/31/19 (about 3.6 years from 6/1/16). It does not appear feasible to meet the regulatory deadline with an estimated project schedule duration of 11.8 years.

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**Table 5(WAB) – WAB Option 3**
**Closure by Removal Option (with East Ash Pond Phases 7-9 Landfill)**
**Summary of Information for Option Evaluation**
**Ash Basin Closure Options Evaluation**
**Roxboro Station**
**Duke Energy**

| Subject | Description |
|---|---|
| | • CAMA Intermediate Hazard - Required date for completion of closure is 12/31/24 (about 7.6 years from 6/1/16). It does not appear feasible meeting the regulatory deadline with an estimated project duration of 11.8 years;<br>• CAMA Low Hazard - Required date for completion of closure is 12/31/29 (about 12.6 years from 6/1/16). It does appear feasible to meet the regulatory deadline with an estimated project duration of 11.8 years. |
| Regional Factors | 1. Beneficial reuse of ash is assumed to continue consistent with current operations.<br>2. Transportation impact (based on miles driven): No off-site impact assumed from vehicle operations.<br>3. Noise impact due to on-site activity (based on proximity of neighbors): On-site noise impact only.<br>4. Visual impact (based on final height of storage facility, land uses within view from the watershed): FGD Pond features to be removed from view. New landfill will be visible from Hyco Lake. |
| Advantages | 1. Complete removal of all ash in the basin and placement within lined landfill.<br>2. No long term environmental monitoring or maintenance required for WAB after ash removal.<br>3. Less miles driven and potentially less air quality impacts than off-site landfill.<br>4. WAB restored to original condition prior to impoundment for ash disposal.<br>5. No property acquisition required.<br>6. No impact on other property owners.<br>7. Operation and maintenance remains within the control of the Roxboro Station. |
| Disadvantages | 1. Could reduce future capacity and impact operations for the EAB landfill. .<br>2. Potential cost and uncertainty for permitting new landfill.<br>3. Logistics of hauling large quantities of ash material over multi-years schedule.<br>4. WAB would be partially inundated after breaching the Main Dam. |

# Table 6(WAB) – WAB Option 4
# Close in Place Hybrid Option (Concept provided for CAP Review)
# Summary of Information for Option Evaluation
# Ash Basin Closure Options Evaluation
# Roxboro Station
# Duke Energy

| Subject | Description |
|---|---|
| Description | For this Hybrid Closure Option, ash material is assumed to be consolidated on the northwest side of the pond area in the vicinity of the FGD pond features. The consolidated ash fill will be closed by placement of an engineered cover system. Site drainage will be provided by a constructed/stabilized channel that runs the length of the pond area and discharges into Hyco Lake through a breach in the main dam. For this closure option, WAP Dike No. 1 is assumed to remain in place for diversion of stormwater through the existing discharge outlet channel.<br><br><u>Reference Drawings</u><br><br>• Drawing WAB0.1 – (General) WAB Assumed Existing Grade<br>• Drawing WAB0.2 – (General) WAB Assumed Original Grade<br>• Drawing WAB4.1 – WAB Closure Option 4 Concept Plan<br>• Drawing WAB4.2 – WAB Closure Option 4 Concept Profiles (Sheet 1 of 2)<br>• Drawing WAB4.3 – WAB Closure Option 4 Concept Profiles (Sheet 2 of 2) |
| Details | 1. It is assumed that the FGD pond and Bio-reactor facilities will be decommissioned and removed prior to implementation of the proposed closure option. The scope and cost for removal of these facilities is not included with evaluation of this option.<br>2. It is also assumed that storm water inflow will be diverted away from WAB by providing a new discharge outlet for the EAB. The scope and cost for EAB storm water diversion is not included with evaluation of this option.<br>3. Dewatering will initially be required for removal of standing water within the WAB. It is anticipated that dewatering will continue to be necessary throughout the excavation and removal of ash material, removal of contaminated soil, and site restoration. The estimated volume of water to be initially removed is around 162 million gallons.<br>4. Ash material will be excavated from the WAP and placed in a stabilized stack in the vicinity of the FGD Pond features. The estimated volume of ash material to be removed and placed in the stabilized stack is around 5,140,645 cy. The slopes for the ash stack are assumed to be 4:1.<br>5. A stabilized drainage channel will be constructed that runs the length of the pond and sloped in the direction from Dike No. 1 to the Main Dam. The invert at the lower end of the discharge channel will be set above Hyco Lake NWL Elev. 410' to avoid potential for standing water under NWL conditions. Based on the conceptual design, placement of about 534,519 cy of fill material will be required to construct the proposed drainage channel at the intended grade elevation. Further engineering review will be required to determine if ash material could be utilized for the channel fill.<br>6. The channel will be subject to periodic flooding for Hyco Lake water level condition above NWL. The estimated water level for the 100 year flood condition is at Elev. 413'. Consideration should be given to channel stabilization possibly with riprap material as needed for flow and periodic flooding conditions. For estimating purposes, we have assumed that the channel will be stabilized with riprap for 25 |

**Table 6(WAB) – WAB Option 4**
**Close in Place Hybrid Option (Concept provided for CAP Review)**
**Summary of Information for Option Evaluation**
**Ash Basin Closure Options Evaluation**
**Roxboro Station**
**Duke Energy**

| Subject | Description |
|---|---|
| | feet on each side of the channel invert (50' width). The placement depth for the riprap is assumed to be 2 feet.<br>7. The cover system for the ash stack area (bottom to top) is assumed to consist of a 40-mil double sided textured LLDPE Geomembrane, Geocomposite Drainage Layer, 18-inch final cover soil, and 6-inch vegetative soil cover layer. The approximate surface area for the cover system is around 77 acres.<br>8. A system for collection and treatment of internal drainage will be provided along the toe of the ash stack.<br>9. Contaminated residual soil will be removed to an assumed minimum depth of 1 foot. The estimated area for removal of contaminated soil is 109 acres and the volume of contaminated soil removed is around 175,853 cy.<br>10. The WAB Main Dam will be breached as required for jurisdictional decommissioning under NCDEQ Dam Safety and to provide post-closure site drainage. It should be noted that the WAB will be partially flooded after breaching the dam. (Hyco Lake NWL is at Elev 410' and 100 year flood level at Elev 413')<br>11. The WAB Dike No. 1 will not be breached for this option. Dike No. 1 will remain in place to divert upstream stormwater runoff to the existing discharge outlet channel. (Note that water level is currently controlled by weir structure with existing crest at Elevation 446'.)<br>12. The existing discharge outlet channel will be drained and ash material removed for the limits of the channel. For estimating purposes, the ash removal cleanup is assumed to include the impoundment area downstream from Dike No. 1 (estimated at 39 acres) and the surface area of the discharge channel (estimated at 6.4 acres. The ash cleanup is estimated based on removal of at least 1 foot of material over the entire area (85,855 cy). The existing structures are also assumed to be removed for closure.<br>13. Permanent surface stabilization measures will be provided for all WAB areas affected by the implementation of this option. The permanent stabilization is expected to primarily consist of seeding and mulching over an estimated area of about 186 acres. .<br>14. The requirements for groundwater monitoring and remediation are not known at the time of this evaluation. The requirements are expected to be confirmed after completion of the SynTerra Groundwater Corrective Action Plan (CAP) Part 2. |
| Environmental Protection and Impacts | 1. Estimated time to achieve compliance with groundwater standards: For Close in Place/Hybrid Options, it is assumed that compliance may require additional time <u>after</u> completion of closure construction activities for implementation of groundwater remediation corrective actions and/or natural attenuation. The requirements for groundwater corrective action will be confirmed by the groundwater SynTerra Corrective Action Plan which is scheduled to be completed by February 29, 2016.<br>2. Residual groundwater-related risk: (e.g. source removed, source remains above groundwater, source remains below groundwater, conduits remain below ash pond) For this closure option, ash material will remain in place below groundwater level and continue to be a potential source of contamination. |

## Table 6(WAB) – WAB Option 4
## Close in Place Hybrid Option (Concept provided for CAP Review)
## Summary of Information for Option Evaluation
## Ash Basin Closure Options Evaluation
## Roxboro Station
## Duke Energy

| Subject | Description |
|---|---|
| | 3. Proximity to riverbank or shoreline: Ash material is currently stored in close proximity to Hyco Lake at the WAB Main Dam. In addition, the existing discharge outlet channel carries flow from the WAB to Hyco Lake. For Closure by Removal Options, the WAB Main Dam will be breached and ash material will no longer be stored in close proximity to Hyco Lake. For this closure option, ash material will continue to be stored within the WAB but will be capped with an engineered cover system.<br>4. Proximity to public drinking water intakes: Based on review of EPA data base, there are no known public water supply systems and intakes located on Hyco Lake or in the vicinity of the Roxboro ash basins. The Hyco River is a tributary stream to the Dan River and is located within the Roanoke River Basin. The closest downstream public water supply intake is believed to be located on the Dan River in South Boston, Virginia. From review of available information, this criteria is not considered applicable for evaluation of closure options.<br>5. Proximity to downgradient public potable water supply well: Public water supply wells were identified by the receptor survey in the CSA Report including a well located at the dry wall plant about 785 feet east of the compliance boundary and two wells located at an elementary school about 2,700 feet west and upgradient from the compliance boundary. For this closure option, ash material will remain in place below groundwater level at the site but is not expected to have potential for impacting upgradient public water supply wells.<br>6. Proximity to private water supply wells: Inventories of of private water supplies wells were compiled as indicated by the CSA Report. Water supply wells are located within 0.5 miles of the site; however these wells are reported to be located upgradient from the Roxboro ash basins. For this closure option, ash material will remain in place below groundwater level at the site but is not expected to have potential for impacting upgradient private water supply wells.<br>7. Proximity to flora, fauna and human receptors: The CSA Report indicates that exposure media for human receptors and ecological receptors includes potentially impacted groundwater, seeps, surface water, soil and sediments. Potential human receptors, current and future, include recreational users and construction/industrial workers and residents. For this closure option, ash material will remain in place but would be capped with an engineered cover system to effectively contain the exposure media; however, the potential for exposure to impacted groundwater and seeps would remain for ash material that continues to be stored below groundwater level.<br>8. Restoration of habitat, streams or wetlands: For Closure by Removal Options, site drainage would generally be restored to the condition prior to impoundment of the WAB. For this closure option, restoration of habitat would be provided to the extent of ash removal. The estimated area to be restored with this closure option is 109 acres. |

## Table 6(WAB) – WAB Option 4
## Close in Place Hybrid Option (Concept provided for CAP Review)
## Summary of Information for Option Evaluation
## Ash Basin Closure Options Evaluation
## Roxboro Station
## Duke Energy

| Subject | Description |
|---|---|
| | 9. Air emissions off-site: Evaluated based on estimated total miles driven for off-site hauling operations. Ash hauling would be all on-site and would be primarily within the limits of the WAB.<br>10. Air emissions on-site: Evaluated based on estimated total miles driven for on-site hauling operations. Ash hauling would be all on-site and would be primarily within the limits of the WAB. The estimated average vehicle travel distance is around 0.5 miles (one way) and the total estimated miles driven for on-site hauling operations is 317,785 miles.<br>11. Avoidance of greenfield disturbance: There are no areas identified for potential greenfield disturbance associated with the closure option. |
| Cost | Total Estimated Cost: $95,420,450<br><br>Long Term O&M/Monitoring Cost: $5,667,000<br><br>Avoided Cost: The cost for development of a landfill will be avoided with this option. |

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# Table 6(WAB) – WAB Option 4
# Close in Place Hybrid Option (Concept provided for CAP Review)
# Summary of Information for Option Evaluation
# Ash Basin Closure Options Evaluation
# Roxboro Station
# Duke Energy

Schedule

Estimated Project Schedule Duration

The estimated duration for the expected critical path activities is shown in the table below. Based on this schedule analysis, the estimated project duration for this option would be about 7.7 years.

| Activity | Activity Description | Est Activity Duration (Months) | Cum Duration (Months) | Cum Duration (Years) |
|---|---|---|---|---|
| 1.0 | Landfill | | | |
| 1.1 | Planning/Preliminary Engineering | 0 | 0 | 0.0 |
| 1.2 | Property Acquisition | 0 | 0 | 0.0 |
| 1.3 | Field Investigation | 0 | 0 | 0.0 |
| 1.4 | Permitting | 0 | 0 | 0.0 |
| 1.5 | Construction Documents | 0 | 0 | 0.0 |
| 1.6 | Bidding | 0 | 0 | 0.0 |
| 1.7 | Landfill Construction | 0 | 0 | 0.0 |
| 1.8 | Landfill PTO | 0 | 0 | 0.0 |
| 2.0 | Closure Implementation (assumed critical path) | - | - | - |
| 2.1 | Permitting | 12 | 12 | 1.0 |
| 2.2 | Construction Documents - Finish concurrent with Activity 2.1 | 6 | 12 | 1.0 |
| 2.3 | Bidding - Start after Activity 2.2 | 3 | 15 | 1.3 |
| 2.4 | Construction Dewatering and Site Preparation | 6 | 21 | 1.8 |
| 2.5 | Ash and Contaminated Soil Excavation/Hauling | 33 | 48 | 4.0 |
| 2.6 | Engineered Cover Construction (77 acres) | 26 | 74 | 6.2 |
| 2.7 | Site Restoration | 18 | 92 | 7.7 |
| | **Estimated Project Duration** | | **92** | **7.7** |

Initial Time to Begin Ash Removal

For this option, the initial time to begin ash removal is estimated to be 1.3years after project start date.

Likelihood of Meeting Regulatory Deadlines

## Table 6(WAB) – WAB Option 4
## Close in Place Hybrid Option (Concept provided for CAP Review)
## Summary of Information for Option Evaluation
## Ash Basin Closure Options Evaluation
## Roxboro Station
## Duke Energy

| Subject | Description |
|---|---|
| | For this review, we have assumed that the closure plan will be completed by 6/1/16 consistent with the current project schedule direction from Duke Energy.<br>• CAMA High Hazard – This closure option would not meet the requirements of the hazard classification.<br>• CAMA Intermediate Hazard - This closure option would not meet the requirements of the hazard classification.<br>• CAMA Low Hazard - Required date for completion of closure is 12/31/29 (about 12.6 years from 6/1/16). It does appear feasible to meet the regulatory deadline with an estimated project duration of 7.7 years. |
| Regional Factors | 1. Beneficial reuse of ash is assumed to continue consistent with current operations.<br>2. Transportation impact (based on miles driven): No off-site impact assumed from vehicle operations.<br>3. Noise impact due to on-site activity (based on proximity of neighbors): On-site noise impact only.<br>4. Visual impact (based on final height of storage facility, land uses within view from the watershed): FGD Pond features to be removed from view. New fill area will be visible from Hyco Lake. |
| Advantages | 1. Some ash deposits to remain in place which will limit excavation and hauling requirements.<br>2. Less miles driven and potentially less air quality impacts than landfill options.<br>3. Does not reduce capacity or impact operations for the EAB landfill.<br>4. WAB partially restored to original condition prior to impoundment for ash disposal.<br>5. No property acquisition required.<br>6. No impact on other property owners.<br>7. Operation and maintenance remains within the control of the Roxboro Station. |
| Disadvantages | 1. Ash deposits will remain in place within unlined areas of the WAB.<br>2. Ash material removed and placed on top of ash deposits (not within lined landfill area).<br>3. Long term environmental monitoring and maintenance required for WAB after partial ash removal.<br>4. Ash deposits will likely remain in place below groundwater level. |

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## Table 7(WAB) – WAB Option 5
## Close in Place Hybrid Option (With minimum excavation and relocation of ash)
## Summary of Information for Option Evaluation
## Ash Basin Closure Options Evaluation
## Roxboro Station
## Duke Energy

| Subject | Description |
|---|---|
| Description | This closure option represents the approach of minimizing the excavation and relocation of ash material within the WAB. For this option, the existing ash deposits will be graded in the direction of Dike No. 1. Site drainage will be provided by lowering the crest of Dike No. 1 to about Elevation 447 feet. It should be noted that the water level downstream from Dike No. 1 is currently controlled by the weir structure at about Elevation 446 feet. This option will result in requiring a significantly larger surface area for closure with an engineered cover system. For this option, the FGD Pond and Bio-reactor Facilities could possibly remain in service throughout the closure plan implementation.<br><br><u>Reference Drawings</u><br><br>• Drawing WAB0.1 – (General) WAB Assumed Existing Grade<br>• Drawing WAB0.2 – (General) WAB Assumed Original Grade<br>• Drawing WAB5.1 – WAB Closure Option 5 Concept Plan |
| Details | 1. For this option, the FGD Pond and Bio-reactor Facilities could remain in service throughout the closure plan implementation. The scope and cost for removal of these facilities is not included with evaluation of this option.<br>2. It is also assumed that storm water inflow will be diverted away from WAB by providing a new discharge outlet for the EAB. The scope and cost for EAB storm water diversion is not included with evaluation of this option.<br>3. Dewatering will initially be required for removal of standing water within the WAB. It is anticipated that dewatering will continue to be necessary throughout the excavation and removal of ash material, removal of contaminated soil, and site restoration. The estimated volume of water to be initially removed is around 162 million gallons.<br>4. The existing ash deposits will be graded to minimize the “footprint” for final closure and to provide adequate site drainage after closure. The final site drainage plan is expected to generally provide overland flow in the direction from the Main Dam to Dike No. 1. The estimated volume of ash material for cut to fill placement associated with site grading is 1,314,364 cy.<br>5. The cover system for the ash material left in place (bottom to top) is assumed to consist of a 40-mil double sided textured LLDPE Geomembrane, Geocomposite Drainage Layer, 18-inch final cover soil, and 6-inch vegetative soil cover layer. The approximate surface area for the cover system is around 186 acres.<br>6. It is assumed that the liner will be extended along the upstream face of Dike No. 1 to provide a seepage barrier.<br>7. A system for collection and treatment of seepage will be provided at the Main Dam and Dike No. 1. The seepage collection system will consist of drainage piping and collection wells. The collected seepage will be pumped to a retention basin for treatment.<br>8. The WAB Main Dam will not be breached for this options. (Hyco Lake NWL is at Elev 410’ and 100 year flood level at Elev 413’)<br>9. The crest of the WAB Dike No. 1 will be lowered to allow overflow for this option. Dike No. 1 will otherwise remain in place to divert upstream stormwater runoff to |

## Table 7(WAB) – WAB Option 5
## Close in Place Hybrid Option (With minimum excavation and relocation of ash)
## Summary of Information for Option Evaluation
## Ash Basin Closure Options Evaluation
## Roxboro Station
## Duke Energy

| Subject | Description |
|---|---|
| | the existing discharge outlet channel. (Note that water level is currently controlled by weir structure with existing crest at Elevation 446'.)<br>10. The existing discharge outlet channel will be drained and ash material removed for the limits of the channel. For estimating purposes, the ash removal cleanup is assumed to include the impoundment area downstream from Dike No. 1 (estimated at 39 acres) and the surface area of the discharge channel (estimated at 6.4 acres. The ash cleanup is estimated based on removal of at least 1 foot of material over the entire area (85,855 cy). The existing structures are also assumed to be removed for closure.<br>11. Permanent surface stabilization measures will be provided for all WAB areas affected by the implementation of this option. The permanent stabilization is expected to primarily consist of seeding and mulching over an estimated area of about 186 acres. .<br>12. The requirements for groundwater monitoring and remediation are not known at the time of this evaluation. The requirements are expected to be confirmed after completion of the SynTerra Groundwater Corrective Action Plan (CAP) Part 2. |
| Environmental Protection and Impacts | 1. Estimated time to achieve compliance with groundwater standards: For Close in Place/Hybrid Options, it is assumed that compliance may require additional time <u>after</u> completion of closure construction activities for implementation of groundwater remediation corrective actions and/or natural attenuation. The requirements for groundwater corrective action will be confirmed by the groundwater SynTerra Corrective Action Plan which is scheduled to be completed by February 29, 2016.<br>2. Residual groundwater-related risk: (e.g. source removed, source remains above groundwater, source remains below groundwater, conduits remain below ash pond) For this closure option, ash material will remain in place below groundwater level and continue to be a potential source of contamination.<br>3. Proximity to riverbank or shoreline: Ash material is currently stored in close proximity to Hyco Lake at the WAB Main Dam. In addition, the existing discharge outlet channel carries flow from the WAB to Hyco Lake. For Closure by Removal Options, the WAB Main Dam will be breached and ash material will no longer be stored in close proximity to Hyco Lake. For this closure option, ash material will continue to be stored within the WAB but will be capped with an engineered cover system.<br>4. Proximity to public drinking water intakes: Based on review of EPA data base, there are no known public water supply systems and intakes located on Hyco Lake or in the vicinity of the Roxboro ash basins. The Hyco River is a tributary stream to the Dan River and is located within the Roanoke River Basin. The closest downstream public water supply intake is believed to be located on the Dan River in South Boston, Virginia. From review of available information, this criteria is not considered applicable for evaluation of closure options. |

## Table 7(WAB) – WAB Option 5
## Close in Place Hybrid Option (With minimum excavation and relocation of ash)
## Summary of Information for Option Evaluation
## Ash Basin Closure Options Evaluation
## Roxboro Station
## Duke Energy

| Subject | Description |
|---|---|
| | 5. Proximity to downgradient public potable water supply well: Public water supply wells were identified by the receptor survey in the CSA Report including a well located at the dry wall plant about 785 feet east of the compliance boundary and two wells located at an elementary school about 2,700 feet west and upgradient from the compliance boundary. For this closure option, ash material will remain in place below groundwater level at the site but is not expected to have potential for impacting upgradient public water supply wells.<br>6. Proximity to private water supply wells: Inventories of of private water supplies wells were compiled as indicated by the CSA Report. Water supply wells are located within 0.5 miles of the site; however these wells are reported to be located upgradient from the Roxboro ash basins. For this closure option, ash material will remain in place below groundwater level at the site but is not expected to have potential for impacting upgradient private water supply wells.<br>7. Proximity to flora, fauna and human receptors: The CSA Report indicates that exposure media for human receptors and ecological receptors includes potentially impacted groundwater, seeps, surface water, soil and sediments. Potential human receptors, current and future, include recreational users and construction/industrial workers and residents. For this closure option, ash material will remain in place but would be capped with an engineered cover system to effectively contain the exposure media; however, the potential for exposure to impacted groundwater and seeps would remain for ash material that continues to be stored below groundwater level.<br>8. Restoration of habitat, streams or wetlands: For Closure by Removal Options, site drainage would generally be restored to the condition prior to impoundment of the WAB. For this closure option, it is assumed that only a small portion of the existing ash pond area will be restored. The estimated area to be restored with this closure option is 0 acres.<br>9. Air emissions off-site: Evaluated based on estimated total miles driven for off-site hauling operations. For this option, site grading for cut to fill of ash deposits would be all on-site within the limits of the WAB.<br>10. Air emissions on-site: Evaluated based on estimated total miles driven for on-site hauling operations. For this option, site grading for cut to fill of ash deposits would be all on-site within the limits of the WAB. For estimating purposes, the average vehicle travel distance is assumed to be around 0.7 miles (one way) and the total estimated miles driven for on-site hauling operations is 65,344 miles.<br>11. Avoidance of greenfield disturbance: For this option, it is assumed that no greenfield disturbance will be required. |
| Cost | Total Estimated Cost: $79,191,749<br><br>Long Term O&M/Monitoring Cost: $5,613,000 |

## Table 7(WAB) – WAB Option 5
## Close in Place Hybrid Option (With minimum excavation and relocation of ash)
## Summary of Information for Option Evaluation
## Ash Basin Closure Options Evaluation
## Roxboro Station
## Duke Energy

| Subject | Description |
|---|---|
| | Avoided Cost: For this option, it may be feasible to design a closure plan that would allow the FGD Pond and Bio-reactor facilities to remain in service. This would avoid the cost for replacement. |

# Table 7(WAB) – WAB Option 5
# Close in Place Hybrid Option (With minimum excavation and relocation of ash)
# Summary of Information for Option Evaluation
# Ash Basin Closure Options Evaluation
# Roxboro Station
# Duke Energy

Schedule

Estimated Project Schedule Duration

The estimated duration for the expected critical path activities is shown in the table below. Based on this schedule analysis, the estimated project duration for this option would be about 8.1 years.

| Activity | Activity Description | Est Activity Duration (Months) | Cum Duration (Months) | Cum Duration (Years) |
|---|---|---|---|---|
| 1.0 | Landfill | | | |
| 1.1 | Preliminary Engineering | 0 | 0 | 0.0 |
| 1.2 | Property Acquisition | 0 | 0 | 0.0 |
| 1.3 | Field Investigation | 0 | 0 | 0.0 |
| 1.4 | Permitting | 0 | 0 | 0.0 |
| 1.5 | Construction Documents | 0 | 0 | 0.0 |
| 1.6 | Bidding | 0 | 0 | 0.0 |
| 1.7 | Landfill Construction | 0 | 0 | 0.0 |
| 1.8 | Landfill PTO | 0 | 0 | 0.0 |
| 2.0 | Closure Implementation (assumed critical path) | | | |
| 2.1 | Permitting | 12 | 12 | 1.0 |
| 2.2 | Construction Documents - Finish concurrent with Activity 2.1 | 6 | 12 | 1.0 |
| 2.3 | Bidding - Start after Activity 2.2 | 3 | 15 | 1.3 |
| 2.4 | Construction Dewatering and Site Preparation | 6 | 21 | 1.8 |
| 2.4 | Ash and Contaminated Soil Excavation/Hauling/Site Grading | 9 | 24 | 2.0 |
| 2.5 | Engineered Cover Construction (186 acres) | 62 | 86 | 7.1 |
| 2.6 | Site Restoration | 12 | 98 | 8.1 |
| | **Estimated Project Duration** | | **98** | **8.1** |

Initial Time to Begin Ash Removal

For this option, the initial time to begin ash removal is estimated to be 1.8 years after project start date.

Likelihood of Meeting Regulatory Deadlines

For this review, we have assumed that the closure plan will be completed by 6/1/16 consistent with the current project schedule direction from Duke Energy.

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## Table 7(WAB) – WAB Option 5
## Close in Place Hybrid Option (With minimum excavation and relocation of ash)
## Summary of Information for Option Evaluation
## Ash Basin Closure Options Evaluation
## Roxboro Station
## Duke Energy

| Subject | Description |
|---|---|
| | • CAMA High Hazard – This closure option would not meet the requirements of the hazard classification.<br>• CAMA Intermediate Hazard - This closure option would not meet the requirements of the hazard classification.<br>• CAMA Low Hazard - Required date for completion of closure is 12/31/29 (about 12.6 years from 6/1/16). It does appear feasible to meet the regulatory deadline with an estimated project duration of 8.1 years. |
| Regional Factors | 1. Beneficial reuse of ash is assumed to continue consistent with current operations.<br>2. Transportation impact (based on miles driven): No off-site impact assumed from vehicle operations.<br>3. Noise impact due to on-site activity (based on proximity of neighbors): On-site noise impact only.<br>4. Visual impact (based on final height of storage facility, land uses within view from the watershed): Existing ash deposits to be graded and capped with no visual impact expected. |
| Advantages | 1. All existing ash deposits will essentially remain in place.<br>2. Less miles driven and potentially less air quality impacts than all other options.<br>3. Does not reduce capacity or impact operations for the EAB Landfill.<br>4. No property acquisition required.<br>5. No impact on other property owners.<br>6. Operation and maintenance remains within the control of the Roxboro Station.<br>7. It may be possible to develop closure plan that would allow continued operation of the FGD Pond and Bio-reactor facilities. |
| Disadvantages | 1. Ash deposits will remain in place within unlined areas of the WAB. .<br>2. Long term environmental monitoring and maintenance required for WAB.<br>3. Potential for surface erosion of the soil cover from stormwater runoff.<br>4. Ash deposits will likely remain below groundwater level.<br>5. Requirements for collecting and treating continued seepage at the Main Dam and Dike No. 1. |

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# Table 8(WAB) – WAB Option 6
## Hybrid Closure Option (Combination of Close In Place and Landfill)
## Summary of Information for Option Evaluation
## Ash Basin Closure Options Evaluation
## Roxboro Station
## Duke Energy

| Subject | Description |
|---|---|
| Description | This option assumes that closure will be accomplished by a combination of Hybrid In-Place Closure and Landfill options. For concept evaluation purposes, we have assumed ash material will be removed from the east side of the WAB to form a stable drainage channel flowing in the direction of the Main Dam (similar to Option 4). The ash material removed will then be relocated to the EAB landfill Phases 7-9. For this option, the FGD Pond and Bio-reactor Facilities could possibly remain in service. All remaining ash fill areas will be closed with an engineered cover system.<br><br><u>Reference Drawings</u><br><br>• Drawing WAB0.1 – (General) WAB Assumed Existing Grade<br>• Drawing WAB0.2 – (General) WAB Assumed Original Grade<br>• Drawing WAB6.1 – WAB Closure Option 6 Concept Plan |
| Details | 1. For this option, the FGD Pond and Bio-reactor Facilities could possibly remain in service throughout the closure plan implementation. The scope and cost for removal of these facilities is not included with evaluation of this option.<br>2. It is also assumed that storm water inflow will be diverted away from WAB by providing a new discharge outlet for the EAB. The scope and cost for EAB storm water diversion is not included with evaluation of this option.<br>3. Dewatering will initially be required for removal of standing water within the WAB. It is anticipated that dewatering will continue to be necessary throughout the excavation and removal of ash material, removal of contaminated soil, and site restoration. The estimated volume of water to be initially removed is around 162 million gallons.<br>4. Ash material will be excavated from the WAB and then transported for disposal within the proposed expansion of EAB Landfill Phases 7-9. The estimated volume of ash material to be removed and placed in the landfill is 5,140,645 cy. The slopes for the remaining ash fill are assumed to be 4:1.<br>5. Contaminated residual soil will be removed to an assumed minimum depth of 1 foot and transported for disposal in the landfill. The estimated area for removal of contaminated soil is 109 acres and the volume of contaminated soil removed is around 175,853 cy.<br>6. The estimated scope, cost and other requirements for development of the on-site landfill will be based on the 2015 Amec Foster Wheeler Landfill Siting Study. It is assumed that a portion of the proposed landfill development for EAB Landfill Phases 7-9 would be utilized for disposal of ash material excavated for the WAB closure. For this option, the landfill development requirements will be proportioned based on: Disposal Volume Ratio (DVR): Option 6 Disposal Volume/Option 3 Disposal Volume = 0.5. The estimated “footprint” for the lined landfill area will be DVR x 86 acres = 43 acres. The total developed area for the landfill including buffers and borrow area development is estimated at DVR x 213 acres = 106 acres. It is assumed that no new property acquisition will be required for this.<br>7. The haul distance between the WAB and the EAB Landfill Phases 7-9 site is estimated to be about 1.1 miles. |

## Table 8(WAB) – WAB Option 6
## Hybrid Closure Option (Combination of Close In Place and Landfill)
## Summary of Information for Option Evaluation
## Ash Basin Closure Options Evaluation
## Roxboro Station
## Duke Energy

| Subject | Description |
|---|---|
| | 8. A stabilized drainage channel will be constructed that runs the length of the pond and sloped in the direction from Dike No. 1 to the Main Dam (consistent with Option 4). The invert at the lower end of the discharge channel will be set above Hyco Lake NWL Elev. 410' to avoid potential for standing water under NWL conditions. Based on the conceptual design, placement of about 534,519 cy of fill material will be required to construct the proposed drainage channel at the intended grade elevation. Further engineering review will be required to determine if ash fill could be utilized for the channel fill.<br>9. The channel will be subject to periodic flooding for Hyco Lake water level condition above NWL. The estimated water level for the 100 year flood condition is at Elev. 413'. Consideration should be given to channel stabilization possibly with riprap material as needed for flow and periodic flooding conditions. For estimating purposes, we have assumed that the channel will be stabilized with riprap for 25 feet on each side of the channel invert (50' width). The placement depth for the riprap is assumed to be 2 feet.<br>10. The cover system for remaining ash deposits left in place (bottom to top) is assumed to consist of a 40-mil double sided textured LLDPE Geomembrane, Geocomposite Drainage Layer, 18-inch final cover soil, and 6-inch vegetative soil cover layer. The estimated area for in place closure is around 77 acres.<br>11. A system for collection and treatment of internal drainage should be provided along the toe of the ash fill adjacent to the drainage channel.<br>12. The WAB Main Dam will be breached as required for jurisdictional decommissioning under NCDEQ Dam Safety and to provide post-closure site drainage. It should be noted that the WAB will be partially flooded after breaching the dam. (Hyco Lake NWL is at Elev 410' and 100 year flood level at Elev 413')<br>13. The WAB Dike No. 1 will not be breached for this option. Dike No. 1 will remain in place to divert upstream stormwater runoff to the existing discharge outlet channel. (Note that water level is currently controlled by weir structure with existing crest at Elevation 446'.)<br>14. The existing discharge outlet channel will be drained and ash material removed for the limits of the channel. For estimating purposes, the ash removal cleanup is assumed to include the impoundment area downstream from Dike No. 1 (estimated at 39 acres) and the surface area of the discharge channel (estimated at 6.4 acres. The ash cleanup is estimated based on removal of at least 1 foot of material over the entire area (85,855 cy). The existing structures are also assumed to be removed for closure. .<br>15. Permanent surface stabilization measures will be provided for all WAB areas affected by the implementation of this option. The permanent stabilization is expected to primarily consist of seeding and mulching over an estimated area of about 186 acres. .<br>16. The requirements for groundwater monitoring and remediation are not known at the time of this evaluation. The requirements are expected to be confirmed after completion of the SynTerra Groundwater Corrective Action Plan (CAP) Part 2. |

**Table 8(WAB) – WAB Option 6**
**Hybrid Closure Option (Combination of Close In Place and Landfill)**
**Summary of Information for Option Evaluation**
**Ash Basin Closure Options Evaluation**
**Roxboro Station**
**Duke Energy**

| Subject | Description |
|---|---|
| Environmental Protection and Impacts | 1. Estimated time to achieve compliance with groundwater standards: For Closure by Removal Options, it is assumed that compliance will be achieved at completion of removal for the ash deposits and contaminated residual soil material. For Close in Place/Hybrid Options, it is assumed that compliance may require additional time after completion of closure construction activities for implementation of groundwater remediation corrective actions and/or natural attenuation. The requirements for groundwater corrective action will be confirmed by the groundwater SynTerra Corrective Action Plan which is scheduled to be completed by February 29, 2016. The project schedule duration will be used as a basis for evaluation of options.<br>2. Residual groundwater-related risk: (e.g. source removed, source remains above groundwater, source remains below groundwater, conduits remain below ash pond) For Close in Place/Hybrid Options, ash material could remain in place below groundwater level and continue to be a potential source of contamination.<br>3. Proximity to riverbank or shoreline: Ash material is currently stored in close proximity to Hyco Lake at the WAB Main Dam. In addition, the existing discharge outlet channel carries flow from the WAB to Hyco Lake. For Close in Place/Hybrid Options, ash material will continue to be stored within the WAB but will be capped with an engineered cover system.<br>4. Proximity to public drinking water intakes: Based on review of EPA data base, there are no known public water supply systems and intakes located on Hyco Lake or in the vicinity of the Roxboro ash basins. The Hyco River is a tributary stream to the Dan River and is located within the Roanoke River Basin. The closest downstream public water supply intake is believed to be located on the Dan River in South Boston, Virginia. From review of available information, this criteria is not considered to be applicable for evaluation of closure options.<br>5. Proximity to downgradient public potable water supply well: Public water supply wells were identified by the receptor survey in the CSA Report including a well located at the dry wall plant about 785 feet east of the compliance boundary and two wells located at an elementary school about 2,700 feet west and upgradient from the compliance boundary. For this closure option, ash material will likely remain in place below groundwater level at the site, but currently does not have potential for impacting upgradient public water supply wells.<br>6. Proximity to private water supply wells: Inventories of of private water supplies wells were compiled as indicated by the CSA Report. Water supply wells are located within 0.5 miles of the site; however these wells are reported to be located upgradient from the Roxboro ash basins. For this closure option, ash material would likely remain in place below groundwater level but currently does not have potential for impacting upgradient private water supply wells.<br>7. Proximity to flora, fauna and human receptors: The CSA Report indicates that exposure media for human receptors and ecological receptors includes potentially impacted groundwater, seeps, surface water, soil and sediments. Potential human |

## Table 8(WAB) – WAB Option 6
## Hybrid Closure Option (Combination of Close In Place and Landfill)
## Summary of Information for Option Evaluation
## Ash Basin Closure Options Evaluation
## Roxboro Station
## Duke Energy

| Subject | Description |
|---|---|
| | receptors, current and future, include recreational users and construction/industrial workers and residents. For this closure option, ash material would remain in place but would be capped with an engineered cover system to effectively contain the exposure media; however, the potential for exposure to impacted groundwater and seeps would remain for ash material that continues to be stored below groundwater level.<br>8. Restoration of habitat, streams or wetlands: For this closure option, restoration of habitat would be provided to the extent of ash removal. The estimated area to be restored with this closure option is 109 acres. .<br>9. Air emissions off-site: Evaluated based on estimated total miles driven for off-site hauling operations. For this closure option, ash hauling and related earthwork would be entirely on Duke Energy property (all on-site).<br>10. Air emissions on-site: Evaluated based on estimated total miles driven for on-site hauling operations. The estimated average vehicle travel distance is around 1.1 miles (one way) and the total estimated miles driven for on-site hauling operations is 699,128 miles.<br>11. Avoidance of greenfield disturbance: The potential greenfield area of disturbance will be associated with landfill development within the proposed EAP Landfill Phases 7-9. The estimated area for potential greenfield disturbance is around 106 acres. |
| Cost | Total Estimated Cost: $157,553,126<br><br>Long Term O&M/Monitoring Cost: $9,498,999 (for 30 years)<br><br>Avoided Cost: For this option, it may be feasible to design a closure plan that would allow the FGD Pond and Bio-reactor facilities to remain in service. This would avoid the cost for replacement of these faciliites. |

# Table 8(WAB) – WAB Option 6
# Hybrid Closure Option (Combination of Close In Place and Landfill)
# Summary of Information for Option Evaluation
# Ash Basin Closure Options Evaluation
# Roxboro Station
# Duke Energy

Schedule

Estimated Project Schedule Duration

The estimated duration for the expected critical path activities is shown in the table below. Based on this schedule analysis, the estimated project duration for this option would be about 8.7 years.

| Activity | Activity Description | Est Activity Duration (Months) | Cum Duration (Months) | Cum Duration (Years) |
|---|---|---|---|---|
| 1.0 | Landfill | | | |
| 1.1 | Preliminary Engineering | 8 | 8 | 0.7 |
| 1.2 | Property Acquisition | 0 | 8 | 0.7 |
| 1.3 | Field Investigation - Finish concurrent with Activity 1.1 | 8 | 8 | 0.7 |
| 1.4 | Permitting | 12 | 20 | 1.7 |
| 1.5 | Construction Documents - Finish concurrent with Activity 1.4 | 6 | 20 | 1.7 |
| 1.6 | Bidding | 3 | 23 | 1.9 |
| 1.7 | Landfill Construction (41 acres) | 14 | 37 | 3.1 |
| 1.8 | Landfill PTO | 3 | 40 | 3.3 |
| 2.0 | Closure Implementation (assumed critical path) | | | |
| 2.1 | Ash and Contaminated Soil Excavation/Hauling | 33 | 73 | 6.1 |
| 2.2 | Engineered Cover Construction (77 acres) | 26 | 99 | 8.2 |
| 2.3 | Site Restoration | 6 | 105 | 8.7 |
| | **Estimated Project Duration** | | **105** | **8.7** |

Initial Time to Begin Ash Removal

For this option, the initial time to begin ash removal is estimated to be 3.3 years after project start date.

Likelihood of Meeting Regulatory Deadlines

For this review, we have assumed that the closure plan will be completed by 6/1/16 consistent with the current project schedule direction from Duke Energy.

- CAMA High Hazard – This closure option would not meet the requirements of the hazard classification.
- CAMA Intermediate Hazard - This closure option would not meet the requirements of the hazard classification.

**Table 8(WAB) – WAB Option 6**
**Hybrid Closure Option (Combination of Close In Place and Landfill)**
**Summary of Information for Option Evaluation**
**Ash Basin Closure Options Evaluation**
**Roxboro Station**
**Duke Energy**

| Subject | Description |
|---|---|
| | • CAMA Low Hazard - Required date for completion of closure is 12/31/29 (about 12.6 years from 6/1/16). It does appear feasible to meet the regulatory deadline with an estimated project duration of 8.7 years. |
| Regional Factors | 1. Beneficial reuse of ash is assumed to continue consistent with current operations.<br>2. Transportation impact (based on miles driven): No off-site impact assumed from vehicle operations.<br>3. Noise impact due to on-site activity (based on proximity of neighbors): On-site noise impact only.<br>4. Visual impact (based on final height of storage facility, land uses within view from the watershed): New landfill area will be visible from Hyco Lake within EAB. No fill placement for ash storage within WAB. |
| Advantages | 1. Ash deposits partially removed and placed in lined landfill.<br>2. Some ash deposits remain in place.<br>3. No stacking of ash material on top of unlined existing ash deposits.<br>4. Placement of engineered cover only on existing ash deposits (not on stacked ash material).<br>5. It may be possible to develop closure plan that would allow continued operation of the FGD Pond and Bio-reactor facilities.<br>6. Less miles driven and potentially less air quality impacts than landfill options.<br>7. WAB partially restored to original condition prior to impoundment for ash disposal.<br>8. No property acquisition required.<br>9. No impact on other property owners.<br>10. Operation and maintenance remains within the control of the Roxboro Station. |
| Disadvantages | 1. Ash deposits will remain in place within unlined areas of the WAB. .<br>2. Long term environmental monitoring and maintenance required for WAB.<br>3. Ash deposits will likely remain below groundwater level.<br>4. Could reduce capacity and impact operations for the EAB Landfill.<br>5. Logistics of hauling large quantities of ash material over multi-years schedule. |

Roxboro Closure Options Evaluation
Duke Energy
Amec Foster Wheeler Project No. 7810150347
ATTACHMENTS

- WAB Drawings


ROXBORO ASH BASIN CLOSURE PROJECT
ROXBORO WEST ASH BASIN (WAB)
WAB ASSUMED EXISTING GRADE
NOT RELEASED FOR CONSTRUCTION
NOT FOR CONSTRUCTION
WAB-0.1
REV. 0
LEGEND
EXISTING MAJOR CONTOUR
EXISTING MINOR CONTOUR
WATER SURFACE
STREAM
200 0 200 400 FT
STORM WATER DRAINAGE FROM WAB
SAROENTS CREEK
WATER SURFACE ELEVATION 446'
DIKE 1
ASSUMED ASH BASIN BOUNDARY
(ASH DISPOSAL LIMITS)
AREA: 185.96 AC.
EXISTING GRADES
DUNNAWAY ROAD
STORM WATER DRAINAGE FROM EAB
WEST ASH POND
MAIN DAM
HYCO LAKE
NML ELEV. 410'
100-YEAR FLOOD ELEV. 413'
SKIMMER STRUCTURE
CONCRETE STRUCTURE
TOP ELEV. 445'
WEIR STRUCTURE
CONTROLS WATER
LEVEL AT ELEV. 440'
EXISTING DISCHARGE OUTLET CHANNEL
TOTAL WATER SURFACE AREA 8.48 ACRES
FGD WEST
SETTLING POND
FGD FLUSH
POND
FGD EAST
SETTLING POND
Environment & Infrastructure
amec foster wheeler
DUKE ENERGY
SCALE AS SHOWN
DWG TYPE DWG
JOB NO. 7810-15-0347
DATE 01/08/2016
FILENAME WAB - 0.1.dwg
DRAWING NO
WAB-0.1
REVISION
0
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TITLE
ROXBORO ASH BASIN CLOSURE PROJECT
ROXBORO WEST ASH BASIN (WAB)
WAB ASSUMED ORIGINAL GRADE
NOT RELEASED FOR CONSTRUCTION
NOT FOR CONSTRUCTION
SEAL
Environment & Infrastructure
amec foster wheeler
DUKE ENERGY
SCALE: AS SHOWN
DES: SRA
DWG TYPE: DWG
DFTR: DMS & SS
JOB NO: 7810-15-0347
CHKD: SRA
DATE: 01/08/2016
ENGR: DMS
FILENAME: WAB - 0.2.dwg
APPD: SRA
DRAWING NO.
REVISION
DWG SIZE
ANSI D
22"x34"
WAB-0.2
0
REV. 0
WAB-0.2
LEGEND
EXISTING / HISTORIC MAJOR CONTOUR
EXISTING / HISTORIC MINOR CONTOUR
200 0 200 400 FT
HISTORICAL ELEVATION: 410'
ASSUMED ASH BASIN BOUNDARY
(ASH DISPOSAL LIMITS)
AREA: 185.96 AC.
HISTORIC TOPOGRAPHY
SHOWN WITHIN THIS
BOUNDARY LINE
DUNNAWAY ROAD
HCO LAKE
WATER SURFACE
ELEVATION: 410'
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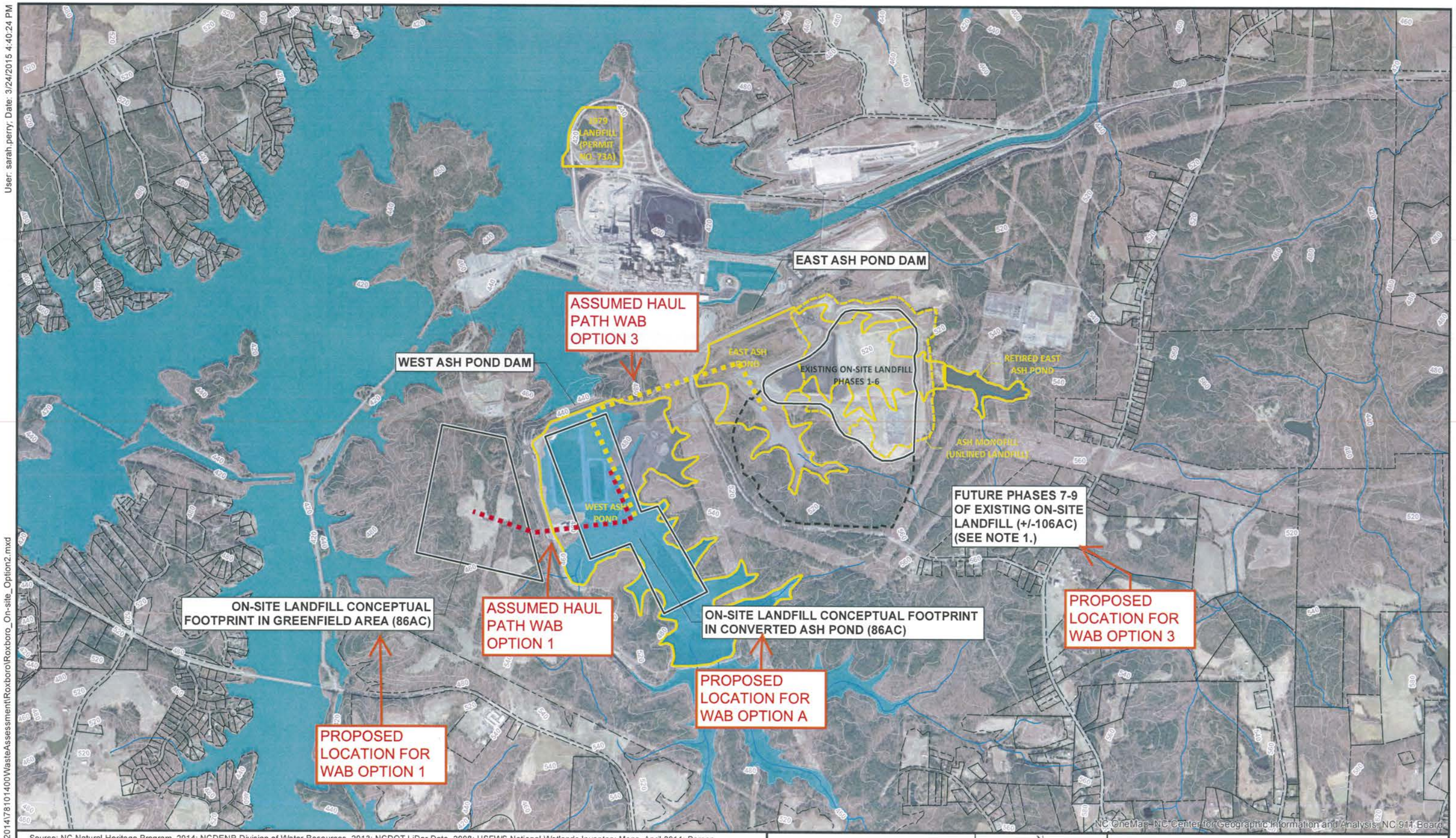



Source: NC Natural Heritage Program, 2014; NCDENR Division of Water Resources, 2013; NCDOT LiDar Data, 2008; USFWS National Wetlands Inventory Maps, April 2014; Person County GIS Datasets, 2014.

Note 1. Phase 7-9 boundary from drawing GEO1 dated 11/1/13 by Blackrock Engineers, Inc.

- APPROXIMATE CONCEPTUAL LANDFILL FOOTPRINT
- APPROXIMATE ASH BOUNDARY
- 1% ANNUAL CHANCE FLOOD HAZARD
- NATIONAL WETLAND INVENTORY
- CONTOUR (20 FOOT)
- STREAMS

amec foster wheeler

N

0 750 1,500 Feet

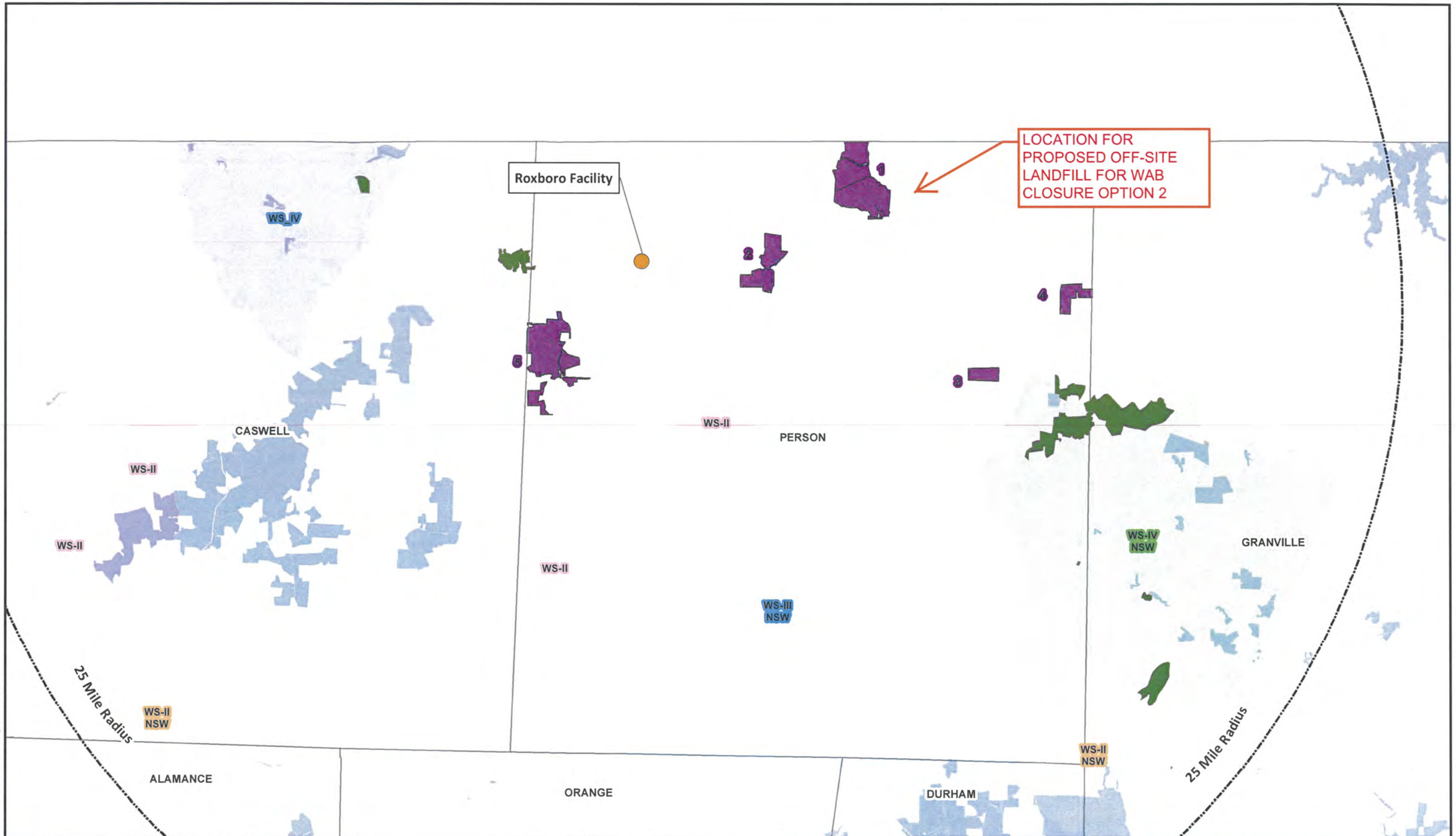
## ON-SITE LANDFILL OPTION

WASTE STRATEGY ANALYSIS
ROXBORO STEAM STATION
NORTH CAROLINA

| PREPARED BY/DATE | JOB NUMBER | FIGURE |
|---|---|---|
| JMS 3/23/2015 | 7810-14-0041 | 7 |

REFERENCE DRAWING FOR ROXBORO ASH BASIN CLOSURE OPTIONS REVIEW - WAB OPTION 1 & OPTION 3

DRAWING WAB1.1 AND WAB3.1




REFERENCE DRAWING FOR ROXBORO ASH BASIN CLOSURE OPTIONS REVIEW - WAB OPTION 2

DRAWING WAB2.1

REFERENCE DRAWING FOR ROXBORO ASH BASIN CLOSURE OPTIONS REVIEW - WAB OPTION 2

DRAWING WAB2.2

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community
Sources: Esri, HERE, Delorme, USGS, Intermap, increment P Corp., NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), TomTom, Mapmyindia, © OpenStreetMap contributors, and the GIS User Community NC Natural Heritage Program, 2014; NCDENR Division of Water Resources, 2013; NCDOT LiDar Data, 2008; USFWS National Wetlands Inventory Maps, April 2014; Person and Caswell County GIS Datasets.

- LANDFILL SITE OPTION
- POTENTIAL DEVELOPABLE AREA
- PARCEL BOUNDARY
- SIGNIFICANT NATURAL HERITAGE AREA
- MANAGED AREAS IN NORTH CAROLINA
- BIODIVERSITY/HABITAT ASSESSMENT AREAS
- NATIONAL WETLAND INVENTORY
- 1% ANNUAL CHANCE FLOOD HAZARD
- CONTOUR (4 FOOT)
- STREAMS

ATTRIBUTES CONTRIBUTING TO THE ANALYSIS INCLUDE:
100 YEAR FLOODZONE, WATER SUPPLY
WATERSHEDS, NATIONAL WETLANDS INVENTORY,
CONVERSATION AREAS, BIODIVERSITY/HABITAT
ASSESSMENT AREAS, COUNTY ZONING, AND
THE USGS HYDROLOGY 300 FOOT BUFFER.

JURISDICTION:PERSON COUNTY
ZONE:RURAL CONSERVATION
POTENTIAL DEVELOPABLE AREA: 654 ACRES

0010-00-86-8362.000

LANDFILL OPTION VICINITY MAP
0 5 10 Miles
Roxboro Facility

HAUL ROUTE- 14.18 MILES
0 1 2 Miles
Roxboro Facility

N
0 800 1,600 Feet

amec foster wheeler

PERSON COUNTY - OPTION 1
WASTE STRATEGY ANALYSIS
ROXBORO STEAM STATION
NORTH CAROLINA

PREPARED BY/DATE CLS-09/30/14
JOB NUMBER 7810-14-0041
FIGURE 2

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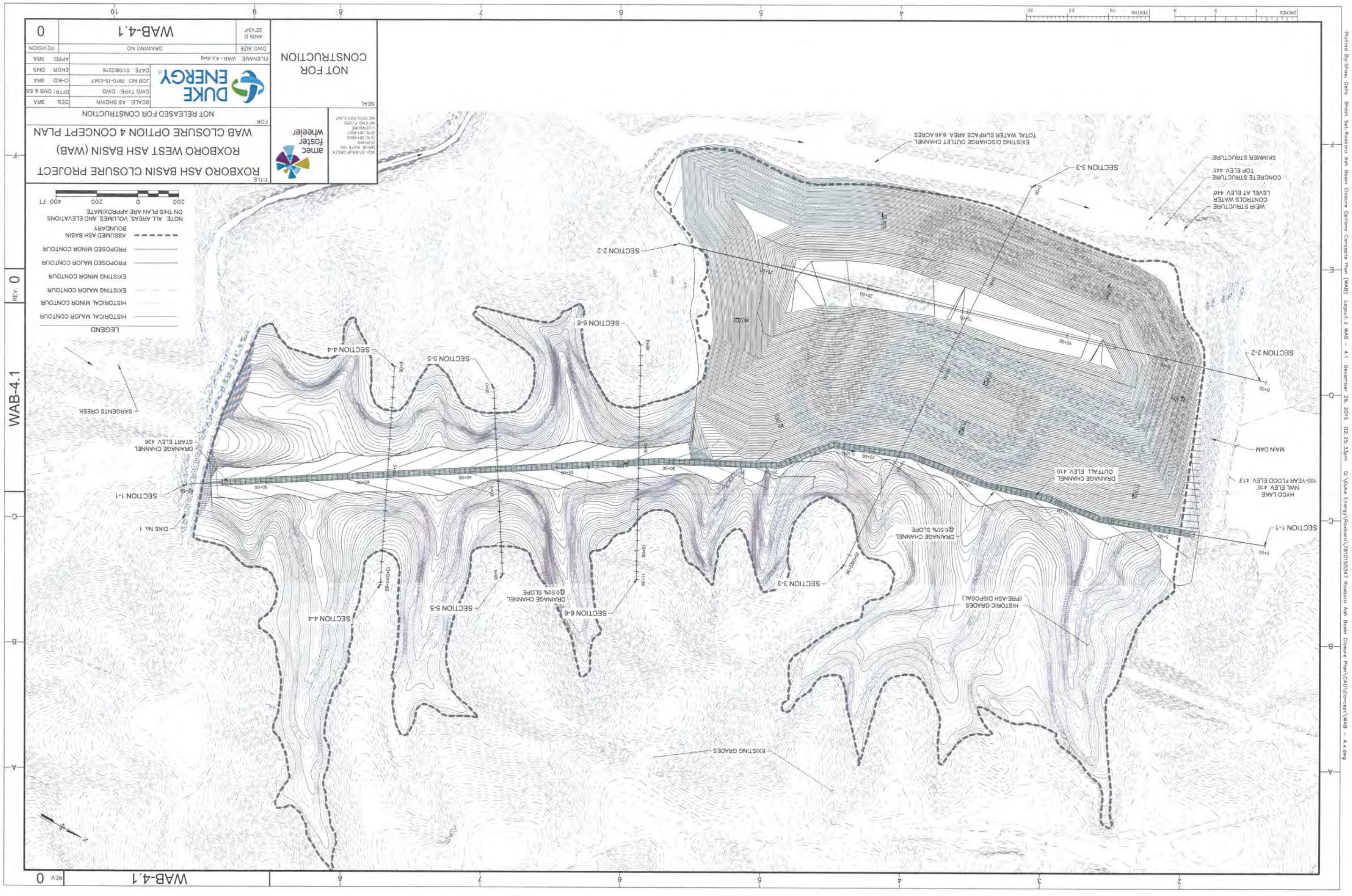
ROXBORO ASH BASIN CLOSURE PROJECT
ROXBORO WEST ASH BASIN (WAB)
WAB CLOSURE OPTION 4 CONCEPT PLAN
NOT RELEASED FOR CONSTRUCTION
NOT FOR CONSTRUCTION
DUKE ENERGY
WAB-4.1
REV. 0
LEGEND
ASSUMED ASH BASIN BOUNDARY
PROPOSED MINOR CONTOUR
PROPOSED MAJOR CONTOUR
EXISTING MINOR CONTOUR
EXISTING MAJOR CONTOUR
HISTORICAL MINOR CONTOUR
HISTORICAL MAJOR CONTOUR
SARGENTS CREEK
DRAINAGE CHANNEL START ELEV. 436
DIKE No. 1
SECTION 1-1
SECTION 2-2
SECTION 3-3
SECTION 4-4
SECTION 5-5
SECTION 6-6
DRAINAGE CHANNEL @ 0.50% SLOPE
EXISTING DISCHARGE OUTLET CHANNEL
TOTAL WATER SURFACE AREA: 8.46 ACRES
WEIR STRUCTURE CONTROLS WATER LEVEL AT ELEV. 446'
CONCRETE STRUCTURE TOP ELEV. 445'
SKIMMER STRUCTURE
DRAINAGE CHANNEL OUTFALL ELEV. 410
MAIN DAM
HVCO LAKE NML ELEV. 410'
100-YEAR FLOOD ELEV. 413'
HISTORIC GRADES (PRE-ASH DISPOSAL)
EXISTING GRADES

| | |
|---|---|
| TITLE | ROXBORO ASH BASIN CLOSURE PROJECT<br>ROXBORO WEST ASH BASIN (WAB)<br>WAB CLOSURE OPTION 4 CONCEPT PROFILES (SHEET 1 OF 2) |
| FOR | NOT RELEASED FOR CONSTRUCTION |
| SCALE | AS SHOWN |
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| JOB NO. | 7810-15-0347 |
| CHKD. | SRA |
| DWG TYPE | DWG |
| DFTR: | DMS & SS |
| DATE | 01/08/2016 |
| ENGR. | DMS |
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| APPD. | SRA |
| DRAWING NO. | WAB-4.2 |
| REVISION | 0 |
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NOT FOR CONSTRUCTION

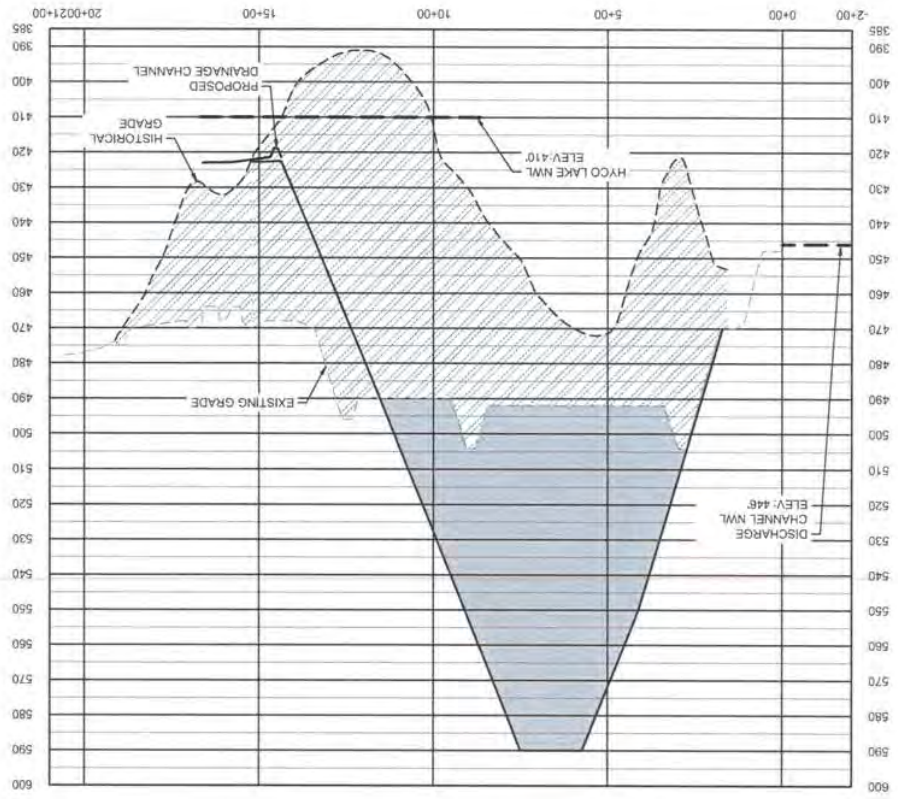
SEAL

amec foster wheeler

DUKE ENERGY

WAB-4.2 REV. 0

SECTION 3-3

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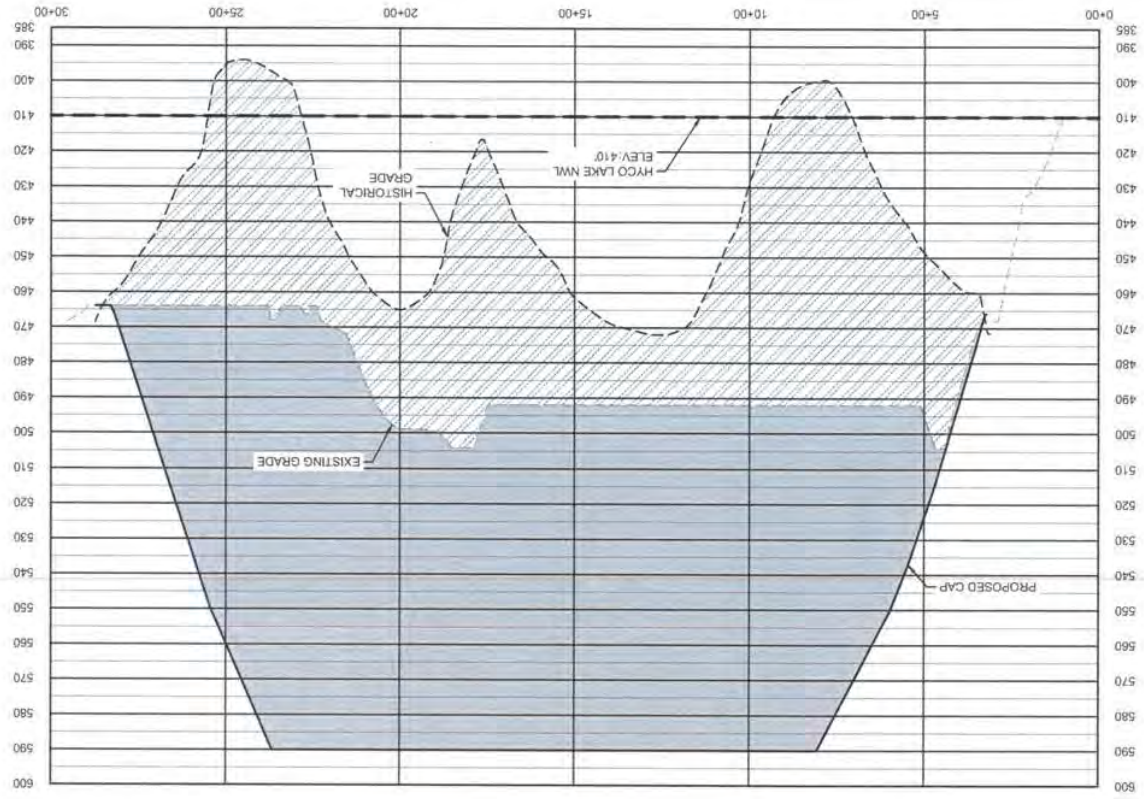


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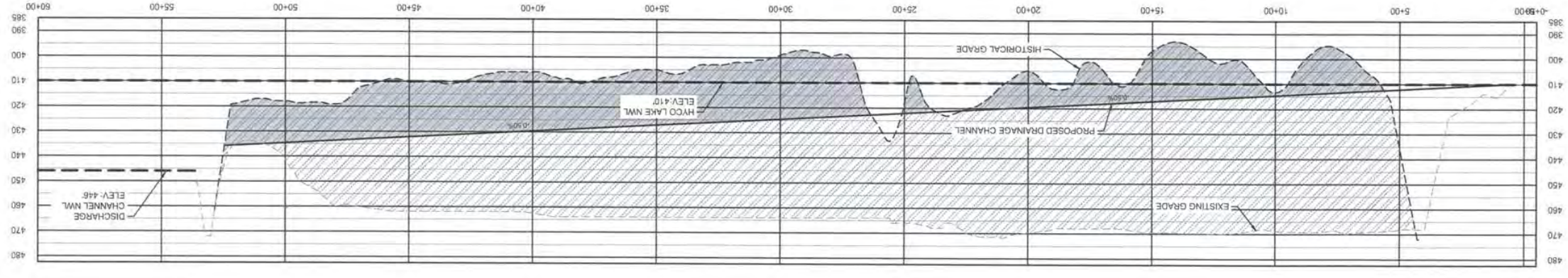
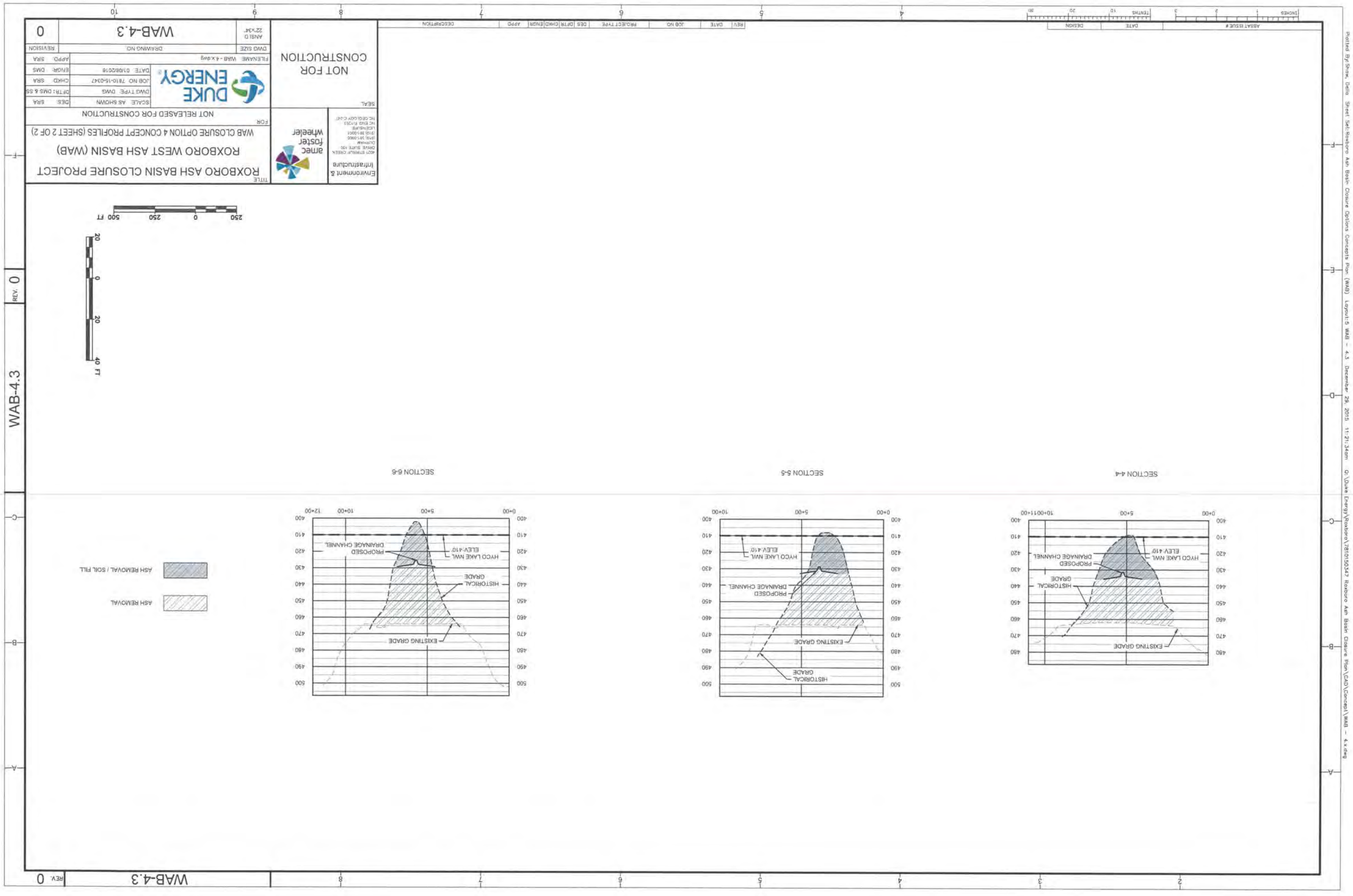



ASH REMOVAL / SOIL FILL

ASH REMOVAL

250 0 250 500 FT

20 0 20 40 FT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ROXBORO ASH BASIN CLOSURE PROJECT
ROXBORO WEST ASH BASIN (WAB)
WAB CLOSURE OPTION 4 CONCEPT PROFILES (SHEET 2 OF 2)
NOT RELEASED FOR CONSTRUCTION
FOR
Environment & Infrastructure
amec foster wheeler
SEAL
NOT FOR CONSTRUCTION
DUKE ENERGY
FILENAME WAB - 4.x.dwg
DATE 01/08/2016
JOB NO 7810-15-0347
DWG TYPE DWG
SCALE AS SHOWN
DES. SRA
DRTR: DMS & SS
CHKD SRA
ENGR DMS
APPD. SRA
DWG SIZE
ANSI D
22"X34"
DRAWING NO.
WAB-4.3
REVISION
0
ASH REMOVAL / SOIL FILL
ASH REMOVAL
SECTION 4-4
SECTION 5-5
SECTION 6-6
HYCO LAKE NWL
ELEV.410'
PROPOSED DRAINAGE CHANNEL
HISTORICAL GRADE
EXISTING GRADE
250 0 250 500 FT
20 0 20 40 FT
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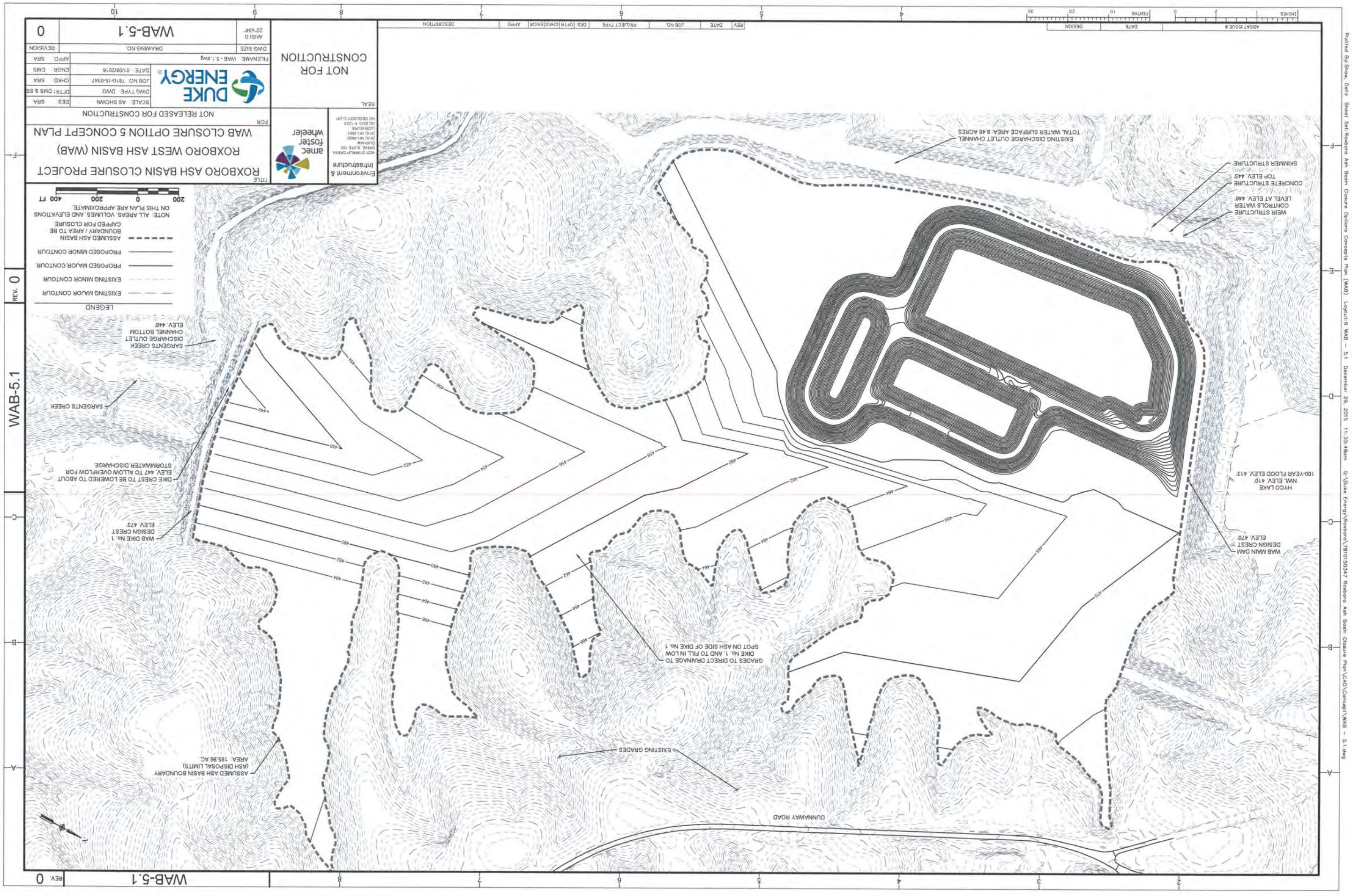
ROXBORO ASH BASIN CLOSURE PROJECT
ROXBORO WEST ASH BASIN (WAB)
WAB CLOSURE OPTION 5 CONCEPT PLAN
NOT RELEASED FOR CONSTRUCTION
NOT FOR CONSTRUCTION
WAB-5.1
REV. 0
LEGEND
EXISTING MAJOR CONTOUR
EXISTING MINOR CONTOUR
PROPOSED MAJOR CONTOUR
PROPOSED MINOR CONTOUR
ASSUMED ASH BASIN BOUNDARY / AREA TO BE CAPPED FOR CLOSURE
NOTE: ALL AREAS, VOLUMES, AND ELEVATIONS ON THIS PLAN ARE APPROXIMATE.
200 0 200 400 FT
SARGENTS CREEK
SARGENTS CREEK DISCHARGE OUTLET CHANNEL BOTTOM ELEV. 445'
DIKE CREST TO BE LOWERED TO ABOUT ELEV. 447 TO ALLOW OVERFLOW FOR STORMWATER DISCHARGE
WAB DIKE No. 1 DESIGN CREST ELEV. 473'
ASSUMED ASH BASIN BOUNDARY (ASH DISPOSAL LIMITS) AREA: 185.96 AC.
EXISTING GRADES
GRADES TO DIRECT DRAINAGE TO DIKE No. 1 AND TO FILL IN LOW SPOT ON ASH SIDE OF DIKE No. 1
DUNNAWAY ROAD
EXISTING DISCHARGE OUTLET CHANNEL TOTAL WATER SURFACE AREA: 8.46 ACRES
SKIMMER STRUCTURE
CONCRETE STRUCTURE TOP ELEV. 445'
WEIR STRUCTURE CONTROLS WATER LEVEL AT ELEV. 445'
HYCO LAKE NML ELEV. 410'
100-YEAR FLOOD ELEV. 413'
WAB MAIN DAM DESIGN CREST ELEV. 470'
Duke ENERGY
Environment & Infrastructure
amec foster wheeler
SCALE: AS SHOWN
DWG TYPE: DWG
JOB NO: 7810-15-0347
DATE: 01/08/2016
FILENAME: WAB - 5.1.dwg
DES: SRA
DFTR: DMS & SS
CHKD: SRA
ENGR: DMS
APPD: SRA
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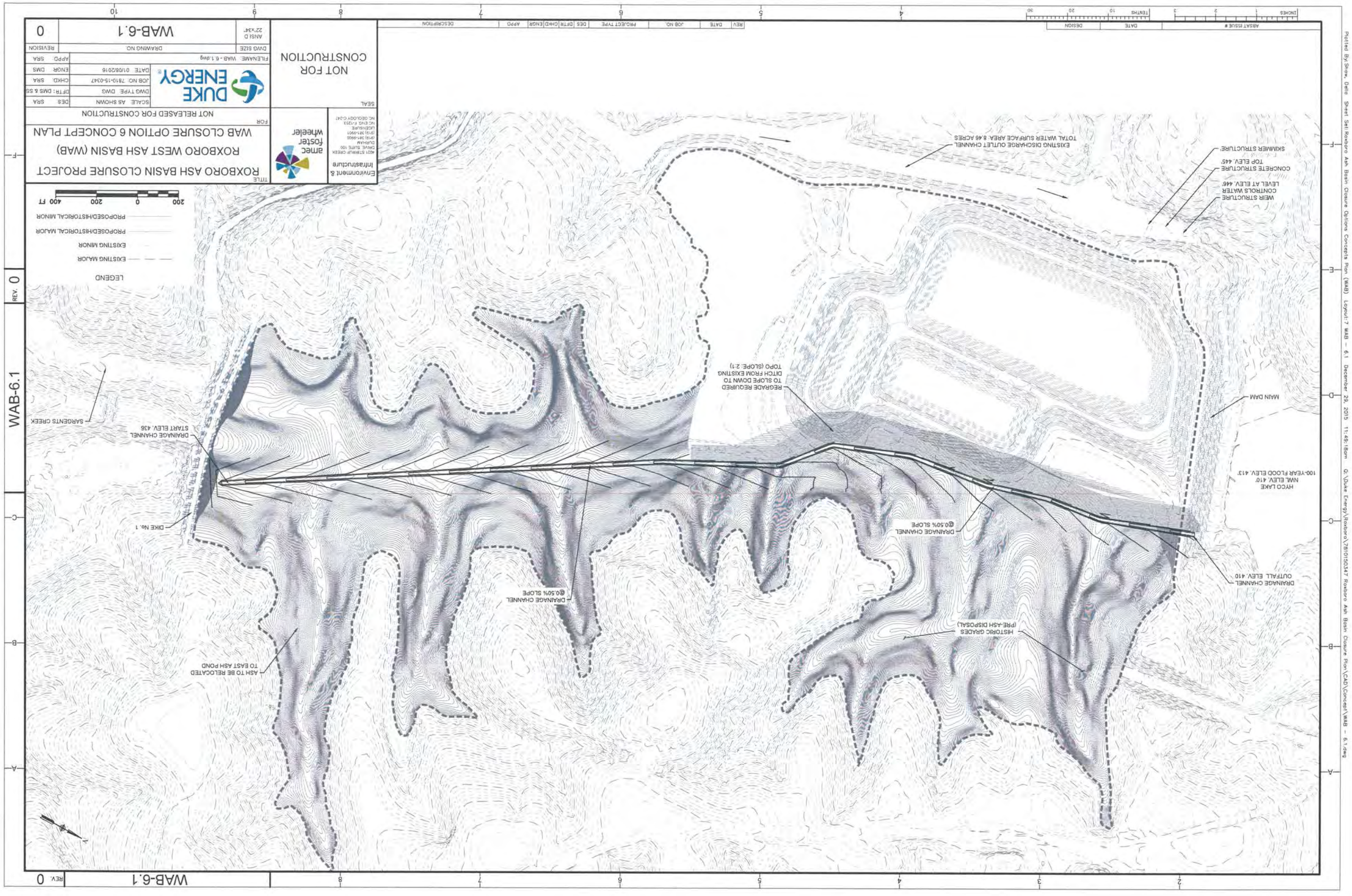
ROXBORO ASH BASIN CLOSURE PROJECT
ROXBORO WEST ASH BASIN (WAB)
WAB CLOSURE OPTION 6 CONCEPT PLAN
NOT RELEASED FOR CONSTRUCTION
NOT FOR CONSTRUCTION
DUKE ENERGY
Environment & Infrastructure
amec foster wheeler
WAB-6.1
REV. 0
LEGEND
EXISTING MAJOR
EXISTING MINOR
PROPOSED/HISTORICAL MAJOR
PROPOSED/HISTORICAL MINOR
200 0 200 400 FT
EXISTING DISCHARGE OUTLET CHANNEL
TOTAL WATER SURFACE AREA: 8.46 ACRES
WEIR STRUCTURE
LEVEL AT ELEV. 446'
CONCRETE STRUCTURE
TOP ELEV. 445'
SKIMMER STRUCTURE
REGRADE REQUIRED TO SLOPE DOWN TO DITCH FROM EXISTING TOPO (SLOPE: 2:1)
MAIN DAM
HYCO LAKE
NML ELEV. 410'
100-YEAR FLOOD ELEV. 413'
SARGENTS CREEK
DRAINAGE CHANNEL START ELEV. 438
DIKE No. 1
DRAINAGE CHANNEL @0.50% SLOPE
DRAINAGE CHANNEL @0.50% SLOPE
DRAINAGE CHANNEL OUTFALL ELEV. 410
HISTORIC GRADES (PRE-ASH DISPOSAL)
ASH TO BE RELOCATED TO EAST ASH POND
Plotted By: Shaw, Delia Sheet Set: Roxboro Ash Basin Closure Options Concepts Plan (WAB) Layout: 7 WAB – 6.1 December 29, 2015 11:49:18am G:\Duke Energy\Roxboro\7810150347 Roxboro Ash Basin Closure Plan\CAD\Concept\WAB – 6.1.dwg

Roxboro Closure Options Evaluation
Duke Energy
Amec Foster Wheeler Project No. 7810150347
ATTACHMENTS

- WAB Cost Estimates

# Roxboro WAB Closure Options
# Closure Option Opinion of Probable Cost - Summary
# Duke Energy - Roxboro Steam Station
# Person County, NC
# 1/8/2016

## Closure Option - Opinion of Probable Cost Summary

| Closure Option | Option Description | Total Estimated Cost | Total Estimated Cost/Acre | Total Estimated Cost/CY | Total Estimated Cost/Ton | Est Post Closure Maint & Monitoring Cost |
|---|---|---|---|---|---|---|
| WAB Option 1 | Closure by Removal (with On-site Landfill) | $160,498,038 | $ 862,893 | $ 15.46 | $ 12.88 | $6,126,000 |
| WAB Option 2 | Closure by Removal (with Off-site Landfill) | $267,468,222 | $ 1,438,001 | $ 25.76 | $ 21.47 | $6,993,000 |
| WAB Option 3 | Closure by Removal (with EAB Phases 7-9 Landfill) | $169,180,628 | $ 909,573 | $ 16.30 | $ 13.58 | $6,126,000 |
| WAB Option 4 | Close in Place Hybrid Option (CAP Concept) | $95,420,450 | $ 513,013 | $ 18.56 | $ 15.47 | $5,667,000 |
| WAB Option 5 | Close in Place Hybrid Option (Minimum Excavation) | $79,191,749 | $ 425,762 | $ 60.25 | $ 50.21 | $11,226,000 |
| WAB Option 6 | Close in Place Hybrid Option (Combination of Close in Place and Landfill) | $157,553,126 | $ 847,060 | $ 30.65 | $ 25.54 | $9,498,000 |

Notes:

1. This is considered to be a Rough Order of Magniture Estimate (ROM Estimate).

2. Total Estimated Cost/Acre based on closure area.

3. Total Estimated Cost/CY based on volume of material removed/ placed in landfill or capped fill area.

4. Total Estimated Cost/Ton based on moist unit weight of material removed/placed in landfill or capped fill area (estimated at 1.2 Tons/CY).

5. Estimated Post Closure Maintenance & Monitoring Cost for landfill and capped fill areas over period of 30 years.

**Roxboro WAB Closure Option 1 - Closure by Removal (with On-Site Landfill)**

**Closure Option Opinion of Probable Cost (ROM)**

**Duke Energy - Roxboro Steam Station**

**Person County, NC**

**1/8/2016**

| | Quantity | Unit | Unit Cost | Total Cost | Estimate Note |
|---|---|---|---|---|---|
| **PROPERTY ACQUISTION** | | | | | |
| Property Acquition Cost | 0 | Acres | $3,000 | $ - | Best estimate of property values in area from review of tax values and for sale listing for large tracts in Person County. NOT VERIFIED. |
| **SUBTOTAL PROPERTY ACQUISTION** | | | | $ - | |
| **GENERAL** | | | | | |
| Mobilization | 1 | LS | | $ - | Estimate at 5% of Final Closure Construction Cost (see below) |
| Surveying | 186 | Acres | $ 2,000 | $ 372,000 | |
| Abandon WAB Discharge Outlet Structures | 2 | EA | $ 150,000 | $ 300,000 | Estimate at $150k/riser |
| **SUBTOTALGENERAL** | | | | $ 672,000 | |
| **EROSION/SEDIMENT CONTROL AND STORMWATER MANAGEMENT** | | | | | |
| West Ash Basin Sediment Control and Stormwater Management | 186 | Acres | $14,000.00 | $ 2,604,000 | Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. Includes silt fence, wattles, surface water diversions, sediment basins, temporary seeding and permanent seeding. |
| Landfill Area Sediment Control and Stormwater Management | 213 | Acres | $14,000.00 | $ 2,982,000 | Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. Includes silt fence, wattles, surface water diversions, sediment basins, temporary seeding and permanent seeding. |
| Bridge or Embankment (with culverts) for discharge channel crossing | 1 | LS | $500,000 | $ 500,000 | Place holder for cost with no technical basis. NOT VERIFIED..... |
| Project Specific Stormewater Management Requirements | | Acres | | $ - | |
| | | | | $ - | |
| | | | | $ - | |
| | | | | $ - | |
| | | | | $ - | |
| **SUBTOTAL EROSION/SEDIMENT CONTROL AND STORMWATER MANAGEMENT** | | | | $ 6,086,000 | |
| **EARTHWORK** | | | | | |
| **Ash Basin Earthwork** | | | | | |
| Construction Entrance | 1000 | LF | $65 | $ 65,000 | Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. |
| Clearing and Grubbing | 5 | Acres | $5,000 | $ 25,000 | Clear and remove vegetation including trees, brush, schrubs. Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. Increased to $5000/acre from review by NWH. |
| Topsoil Stripping | 5 | Acres | $4,000 | $ 20,000 | Strip topsoil to a minimum 6-inch depth and place in stockpile. Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. Incresed to $4000/acre from review by NWH. |
| Earthwork Cut to Waste | 0 | CY | $6.25 | $ - | Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. |
| Earthwork Cut to Fill | 10,000 | CY | $6.25 | $ 62,500 | Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. |
| Soil Material (18 inches, minimum, source material on-site ) | | CY | $13 | $ - | Load, haul, place, and grade common borrow soil material. Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. |
| Topsoil Material; if required (6-inch thick un-compacted fill, source material off-site) | | CY | $13 | $ - | Load, haul, place, and grade topsoil material. Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. |
| **Landfill Earthwork** | | | | | |
| Construction Entrance | 1000 | LF | $65 | $ 65,000 | Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. |
| Clearing and Grubbing | 200 | Acres | $5,000 | $ 1,000,000 | Clear and remove vegetation including trees, brush, schrubs. Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. Increased to $5000/acre from review by NWH. |
| Topsoil Stripping | 200 | Acres | $4,000 | $ 800,000 | Strip topsoil to a minimum 6-inch depth and place in stockpile. Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. Incresed to $4000/acre from review by NWH. |
| Earthwork cut to fill | 1,700,000 | CY | $5.40 | $ 9,180,000 | Grade the site following ash material removal to promote storm water management; grading will be performed to balance cut/fill related to remaining dike/berm soil materials. Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. |
| Stockpiling of Excavation Soils | 2,000,000 | CY | $0.50 | $ 1,000,000 | Grade the site following ash material removal to promote storm water management; grading will be performed to balance cut/fill related to remaining dike/berm soil materials. Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. |
| Perimeter Grading | 50000 | CY | $5.40 | $ 270,000 | Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. |
| Soil Material (18 inches, minimum, source material on-site ) | | CY | $13 | $ - | Load, haul, place, and grade common borrow soil material. Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. |
| Topsoil Material; if required (6-inch thick un-compacted fill, source material off-site) | | CY | $13 | $ - | Load, haul, place, and grade topsoil material. Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. |
| **SUBTOTAL EARTHWORK** | | | | $ 12,487,500 | |
| **ASH BASIN DEWATERING, EXCAVATION, HAULING AND PLACEMENT** | | | | | |
| Temporary Dewatering for WAB Free Water (Estimate 162 million gallons) | 500 | Hours | $750.00 | $ 375,000 | Estimate based on Roxboro West Ash Pond H&H Issuses Improvement Plan, Dewatering/Pumping Plan. Assume drawdown limited to 1 foot/day will require pumping capacity of about 7500 GPM. Estimated time required for initial drawdown: 162,000,000 Gal/7500 GPM x 60 = 360 hours. Use 500 hours for estimating purposes to provide est contingency. Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. |
| Temporary Dewatering for WAB base inflow and stormwater during construction (assume duration of construction to be 5.5 years) | 8,030 | Hours | $750.00 | $ 6,022,500 | Estimate pumping required intermittently for duration of excavation to handle base flow and stormwater inflow. For estimating purposes, assume that pumping will be required for at least 4 hours/day for duration of construction. 4 hr/day x 365 days/yr x 5.5 year construction duration = 8030 hrs. Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates.. |
| Temporary Dewatering for WAB Discharge Channel Free Water (Estimate 7.5 million gallons) | 100 | Hours | $750.00 | $ 75,000 | Assume drawdown with pumping capacity of 2000 GPM. Estimated time required for initial drawdown: 7,500,000 Gal//2000 GPM x 60 = 62.5 hours. Use 100 hours for estimating purposes. Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. No adjustment for pumping capacity recommended for pumping unit cost. |
| Temporary Dewatering for WAB base inflow and stormwater during construction (assume duration of construction to be 6 months) | 730 | Hours | $750.00 | $ 547,500 | Estimate pumping required intermittently for duration of excavation to handle base flow and stormwater inflow. For estimating purposes, assume that pumping will be required for at least 4 housr/day for duration of construction. 4 hr/day x 365 days/yr x 0.5 year construction duration = 730 hrs. Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates.. |
| Water Treatment/Management | 1 | LS | $500,000 | $ 500,000 | Place holder for cost with no technical basis. NOT VERIFIED..... |
| Haul Road Construction | 6,000 | LF | $60 | $ 360,000 | Amec Foster Wheeler experience based on 12-inch thick ABC and supporting geotextile at 20-foot width. Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. |
| Excavation and Loading of Pond Ash for Truck Hauling | 10,382,000 | CY | $2.50 | $ 25,955,000 | Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. |
| Excavation and Loading of Subsurface Soils for Truck Hauling | 300,080 | CY | $2.50 | $ 750,200 | Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. |
| (On-Road) Hauling of Pond Ash and Impacted Soils for Off-site Landfill __ miles | | CY | $6.50 | $ - | Haul with on road dump trucks assumed with 17 cy max capacity. Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. Adjust for on road and distance using look up table. |
| (Off Road) Hauling of Pond Ash and Impacted Soils for On-site Landfill 1.0 miles | 10,767,935 | CY | $2.05 | $ 22,074,267 | Haul with off road dump trucks assumed with 17 cy max capacity. Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. Adjust for off road and distance using look up table. Use rate of $2.05/cy min. |
| Placement of Pond Ash and Impacted Soils In Landfill (Use placed volume) | 8,614,348 | CY | $1.31 | $ 11,284,796 | Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. |
| Truck Wash | 4 | EA | $150,000 | $ 600,000 | Truck wash necessary to clean tires and undercarriage of trucks for over-the-road hauling. Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. |
| Bridge Repair and Maintenance | 0 | LS | $500,000 | $ - | Placed holder estimate for potential bridge repair and maintenance cost. NOT VERIFIED. |
| Paved Haul Road Repair | 1,000 | LF | $120 | $ 120,000 | Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. |
| **SUBTOTAL ASH BASIN DEWATERING, EXCAVATION, HAULING AND PLACEMENT** | | | | $ 68,664,263 | |
| **LANDFILL & CLOSE IN PLACE COVER CONSTRUCTION** | | | | | |
| **Liner System Construction** | | | | | |
| Anchor Trench | 9,000 | LF | 6.00 | $ 54,000 | Unit Cost based on Amec Foster Wheeler experience and previous landfill cost estimates. |
| 8 oz/sy Non-Woven Geotextile | 416,240 | SY | 3.00 | $ 1,248,720 | Furnish and install geotextile as a cushion layer. Unit costs from Glover; costs typically include material, QC testing, and installation |
| Geosynthetic Clay Liner | 3,746,160 | SF | 0.73 | $ 2,734,697 | Unit Cost based on Amec Foster Wheeler experience and previous landfill cost estimates. |
| Textured 60-mil HDPE Geomembrane | 3,746,160 | SF | 0.64 | $ 2,397,542 | Unit Cost based on Amec Foster Wheeler experience and previous landfill cost estimates. |
| Geocomposite Drainage Layer | 3,746,160 | SF | $0.91 | $ 3,409,006 | Unit Cost based on Amec Foster Wheeler experience and previous landfill cost estimates. |
| Protective Cover Fill | 138,747 | CY | $13.00 | $ 1,803,707 | Unit Cost based on Amec Foster Wheeler experience and previous landfill cost estimates. |

## Roxboro WAB Closure Option 1 - Closure by Removal (with On-Site Landfill)

## Closure Option Opinion of Probable Cost (ROM)

## Duke Energy - Roxboro Steam Station

## Person County, NC

## 1/8/2016

| | Quantity | Unit | Unit Cost | Total Cost | Estimate Note |
|---|---|---|---|---|---|
| Drainage Aggregate for Sump | 375 | CY | $67.00 | $ 25,125 | Unit Cost based on Amec Foster Wheeler experience and previous landfill cost estimates. |
| Fine Aggregate for Sump | 65 | CY | $55.00 | $ 3,575 | Unit Cost based on Amec Foster Wheeler experience and previous landfill cost estimates. |
| LCS Riser Pipes | 285 | LF | $190.00 | $ 54,150 | Unit Cost based on Amec Foster Wheeler experience and previous landfill cost estimates. |
| **Cover System Construction** | | | | | |
| Subgrade Preparation | 86 | Acres | $5,000.00 | $ 430,000 | Grade surface of subbase prior to installation of final cover system. Unit costs from construction contractor |
| Anchor Trench | 9,000 | LF | $6.00 | $ 54,000 | Furnish and install geotextile as a cushion layer. Unit costs from Glover; costs typically include material, QC testing, and installation |
| Geosynthetic Clay Liner (GCL) - Not required | 0 | SF | $0.73 | $ - | Furnish and install geotextile as a cushion layer. Unit costs from Glover; costs typically include material, QC testing, and installation |
| 8 oz/sy Non-Woven Geotextile | 416,240 | SY | 3.00 | $ 1,248,720 | Furnish and install geotextile as a cushion layer. Unit costs from Glover; costs typically include material, QC testing, and installation |
| Cover System Geosynthetics (40-mil LLDPE Geomembrane and Geocomposite Drainage Layer | 3,746,160 | SF | $1.45 | $ 5,431,932 | Unit Cost based on Amec Foster Wheeler experience and previous landfill cost estimates. |
| Cover System 18" Soil Cover | 208,120 | CY | $5.50 | $ 1,144,660 | Unit Cost based on Amec Foster Wheeler experience and previous landfill cost estimates. |
| Cover System 6" Top Soil Placement | 69,373 | CY | $11.00 | $ 763,107 | Unit Cost based on Amec Foster Wheeler experience and previous landfill cost estimates. |
| **Close in Place Option Cover System Construction** | | | | | |
| Subgrade Preparation | 0 | Acres | $5,000.00 | $ - | Grade surface of subbase prior to installation of final cover system. Unit costs from construction contractor |
| Anchor Trench | 0 | LF | $6.00 | $ - | Furnish and install geotextile as a cushion layer. Unit costs from Glover; costs typically include material, QC testing, and installation |
| Geosynthetic Clay Liner (GCL) - Not required | 0 | SF | $0.73 | $ - | Furnish and install geotextile as a cushion layer. Unit costs from Glover; costs typically include material, QC testing, and installation |
| 8 oz/sy Non-Woven Geotextile | 0 | SY | 3.00 | $ - | Furnish and install geotextile as a cushion layer. Unit costs from Glover; costs typically include material, QC testing, and installation |
| Cover System Geosynthetics (40-mil LLDPE Geomembrane and Geocomposite Drainage Layer | 0 | SF | $1.45 | $ - | Unit Cost based on Amec Foster Wheeler experience and previous landfill cost estimates. |
| Cover System 18" Soil Cover | | CY | $5.50 | $ - | Unit Cost based on Amec Foster Wheeler experience and previous landfill cost estimates. |
| Cover System Top Soil Placement | | CY | $11.00 | $ - | Unit Cost based on Amec Foster Wheeler experience and previous landfill cost estimates. |
| **SUBTOTAL LANDFILL CONSTRUCTION** | | | | **$ 20,802,940** | |
| | | | | | |
| **SUBTOTAL FINAL CLOSURE CONSTRUCTION COST** | | | | **$ 108,712,703** | |
| **Estimate Mobilization Cost (5% of Final Closure Construction Cost)** | | | | **$ 5,435,635** | |
| **OTHER COST** | | | | | |
| **Design, Permitting and CQA** | | | | | |
| Closure Design/Engineering/Permitting (10% of Final Closure Construction Costs) | 1 | LS | $ 10,871,270 | $ 10,871,270 | Amec Foster Wheeler experience from previous projects |
| Construction Quality Assurance (CQA) (12% of Final Closure Construction Costs) | 1 | LS | $ 13,045,524 | $ 13,045,524 | Amec Foster Wheeler experience from previous projects |
| **Subtotal Design, Permitting and CQA** | | | | **$ 23,916,795** | |
| **Post Closure Operations and Maintenance (analysis based on 30 year duration)** | | | | | |
| Close in Place (Capped) Area Maintenance ( 0 acres) | 0 | YR | $ - | $ - | Estimate at $1700/acre/year of capped area. |
| Close in Place (Capped) Area Monitoring | 0 | YR | $ 58,000 | $ - | Amec Foster Wheeler experience from previous projects |
| Landfill Area Maintenance (86 acres) | 30 | YR | $ 146,200 | $ 4,386,000 | Estimate at $1700/acre/year of lined landfill area. |
| Landfill Area Monitoring | 30 | YR | $ 58,000 | $ 1,740,000 | Amec Foster Wheeler experience from previous projects |
| **Subtotal Post Closure Operations and Maintenance** | | | | **$ 6,126,000** | |
| **Additional Costs** | | | | | |
| Contingency (15% of Final Closure Construction Costs) | 1 | LS | $ 16,306,905 | $ 16,306,905 | Amec Foster Wheeler experience from previous projects |
| **Subtotal Additional Costs** | | | | **$ 16,306,905** | |
| | | | | | |
| **TOTAL OPINION OF PROBABLE CLOSURE COST** | | | | **$ 160,498,038** | Rough Order of Magniture Cost Estimate |
| **OPINION OF PROBABLE CLOSURE COST PER CY** | | | | **$ 15.46** | Based on Volume Placed in landfill |
| **OPINION OF PROBABLE CLOSURE COST PER TON** | | | | **$ 12.88** | Based on Moist Unit Weight of 1.2 Tons/CY |
| **OPINION OF PROBABLE CLOSURE COST PER ACRE** | | | | **$ 862,893** | Based on Estimated Closue Area |

**ESTIMATED QUANTITIES**

| Description | Est Quantity | Units |
|---|---|---|
| Estimated Landfill Property Area: | 0 | Acres |
| Estimated Landfill Development Area (including buffer and borrow area): | 213 | Acres |
| Estimated Lined Landfill Area: | 86 | Acres |
| Estimated West Ash Basin Closure Area: | 186 | Acres |
| Estimated WAB Restoration Area (after ash removal): | 186 | Acres |
| Estimated Ash Material Removed/Hauled Volume: | 10,382,000 | CY |
| Estimated Ash Material Removed/Hauled Moist Wt: | 12,458,400 | Tons (bsed on 1.2 Tons/CY Moist Unit Wt) |
| Estimated Contaminated Soil Removed/Hauled Volume (WAB): | 300,080 | CY |
| Estimated Contaminated Soil Removed/Hauled Volume (Disch Channel): | 85,855 | CY |
| Estimated Contaminated Soil Removed/Hauled Moist Wt: | 578,903 | Tons (based on 1.5 Tons/CY Moist Unit Wt) |
| Total Estimated Ash and Contaminated Soil Removed/Hauled Volume: | 10,767,935 | CY |
| Total Estimated Ash and Contaminated Soil Removed/Hauled Moist Wt: | 13,037,303 | Tons (based on Moist Unit Wt ) |
| Total Estimated Ash and Contaminated Soil Placed in Landfill Volume: | 8,614,348 | Tons (based on 0.8 x Volume Hauled ) |

**Estimate Notes:**

1. This estimate is represented as Rough Order of Magnitude (ROM).

**Roxboro WAB Closure Option 2 - Closure by Removal (with Off-Site Landfill)**

**Closure Option Opinion of Probable Cost (ROM)**

**Duke Energy - Roxboro Steam Station**

**Person County, NC**

**1/8/2016**

| | Quantity | Unit | Unit Cost | Total Cost | Estimate Note |
|---|---|---|---|---|---|
| **PROPERTY ACQUISTION** | | | | | |
| Property Acquition Cost | 400 | Acres | $3,000 | $ 1,200,000 | Best estimate of property values in area from review of tax values and for sale listing for large tracts in Person County. NOT VERIFIED. |
| **SUBTOTAL PROPERTY ACQUISTION** | | | | $ 1,200,000 | |
| **GENERAL** | | | | | |
| Mobilization | 1 | LS | | $ - | Estimate at 5% of Final Closure Construction Cost (see below) |
| Surveying | 586 | Acres | $ 2,000 | $ 1,172,000 | |
| Abandon WAB Discharge Outlet Structures | 2 | EA | $ 150,000 | $ 300,000 | Estimate at $150k/riser |
| **SUBTOTALGENERAL** | | | | $ 1,472,000 | |
| **EROSION/SEDIMENT CONTROL AND STORMWATER MANAGEMENT** | | | | | |
| West Ash Basin Sediment Control and Stormwater Management | 186 | Acres | $14,000.00 | $ 2,604,000 | Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. Includes silt fence, wattles, surface water diversions, sediment basins, temporary seeding and permanent seeding. |
| Landfill Area Sediment Control and Stormwater Management | 250 | Acres | $14,000.00 | $ 3,500,000 | Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. Includes silt fence, wattles, surface water diversions, sediment basins, temporary seeding and permanent seeding. |
| Project Specific Stormewater Management Requirements | | Acres | | $ - | Add for specific drainage requirements such as armoring with riprap. |
| Project Specific Stormewater Management Requirements | | Acres | | $ - | |
| | | | | $ - | |
| | | | | $ - | |
| | | | | $ - | |
| | | | | $ - | |
| **SUBTOTAL EROSION/SEDIMENT CONTROL AND STORMWATER MANAGEMENT** | | | | $ 6,104,000 | |
| **EARTHWORK** | | | | | |
| **Ash Basin Earthwork** | | | | | |
| Construction Entrance | 1000 | LF | $65 | $ 65,000 | Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. |
| Clearing and Grubbing | 5 | Acres | $5,000 | $ 25,000 | Clear and remove vegetation including trees, brush, schrubs. Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. Increased to $5000/acre from review by NWH. |
| Topsoil Stripping | 5 | Acres | $4,000 | $ 20,000 | Strip topsoil to a minimum 6-inch depth and place in stockpile. Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. Incresed to $4000/acre from review by NWH. |
| Clearing and Grubbing | 5 | Acres | $5,000 | $ 25,000 | Clear and remove vegetation including trees, brush, schrubs. Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. Increased to $5000/acre from review by NWH. |
| Earthwork Cut to Waste | 0 | CY | $6.25 | $ - | Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. |
| Earthwork Cut to Fill | 10,000 | CY | $6.25 | $ 62,500 | Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. |
| Soil Material (18 inches, minimum, source material on-site ) | | CY | $13 | $ - | Load, haul, place, and grade common borrow soil material. Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. |
| Topsoil Material; if required (6-inch thick un-compacted fill, source material off-site) | | CY | $13 | $ - | Load, haul, place, and grade topsoil material. Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. |
| **Landfill Earthwork** | | | | | |
| Construction Entrance | 1000 | LF | $65 | $ 65,000 | Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. |
| Clearing and Grubbing | 200 | Acres | $5,000 | $ 1,000,000 | Clear and remove vegetation including trees, brush, schrubs. Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. Increased to $5000/acre from review by NWH. |
| Topsoil Stripping | 200 | Acres | $4,000 | $ 800,000 | Strip topsoil to a minimum 6-inch depth and place in stockpile. Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. Incresed to $4000/acre from review by NWH. |
| Earthwork cut to fill | 1,700,000 | CY | $5.40 | $ 9,180,000 | Grade the site following ash material removal to promote storm water management; grading will be performed to balance cut/fill related to remaining dike/berm soil materials. Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. |
| Stockpiling of Excavation Soils | 2,000,000 | CY | $0.50 | $ 1,000,000 | Grade the site following ash material removal to promote storm water management; grading will be performed to balance cut/fill related to remaining dike/berm soil materials. Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. |
| Perimeter Grading | 50000 | CY | $5.40 | $ 270,000 | Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. |
| Soil Material (18 inches, minimum, source material on-site ) | | CY | $13 | $ - | Load, haul, place, and grade common borrow soil material. Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. |
| Topsoil Material; if required (6-inch thick un-compacted fill, source material off-site) | | CY | $13 | $ - | Load, haul, place, and grade topsoil material. Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. |
| **SUBTOTAL EARTHWORK** | | | | $ 12,512,500 | |
| **ASH BASIN DEWATERING, EXCAVATION, HAULING AND PLACEMENT** | | | | | |
| Temporary Dewatering for WAB Free Water (Estimate 162 million gallons) | 500 | Hours | $750.00 | $ 375,000 | Estimate based on Roxboro West Ash Pond H&H Issuses Improvement Plan, Dewatering/Pumping Plan. Assume drawdown limited to 1 foot/day will require pumping capacity of about 7500 GPM. Estimated time required for initial drawdown: 162,000,000 Gal/7500 GPM x 60 = 360 hours. Use 500 hours for estimating purposes to provide est contingency. Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. |
| Temporary Dewatering for WAB base inflow and stormwater during construction (assume duration of construction to be 10.7 years) | 15,622 | Hours | $750.00 | $ 11,716,500 | Estimate pumping required intermittently for duration of excavation to handle base flow and stormwater inflow. For estimating purposes, assume that pumping will be required for at least 4 hours/day for duration of construction. 4 hr/day x 365 days/yr x 10.7 year construction duration = 8030 hrs. Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates.. |
| Temporary Dewatering for WAB Discharge Channel Free Water (Estimate 7.5 million gallons) | 100 | Hours | $750.00 | $ 75,000 | Assume drawdown with pumping capacity of 2000 GPM. Estimated time required for initial drawdown: 7,500,000 Gal//2000 GPM x 60 = 62.5 hours. Use 100 hours for estimating purposes. Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. No adjustment for pumping capacity recommended for pumping unit cost. |
| Temporary Dewatering for WAB base inflow and stormwater during construction (assume duration of construction to be 6 months) | 730 | Hours | $750.00 | $ 547,500 | Estimate pumping required intermittently for duration of excavation to handle base flow and stormwater inflow. For estimating purposes, assume that pumping will be required for at least 4 housr/day for duration of construction. 4 hr/day x 365 days/yr x 0.5 year construction duration = 730 hrs. Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates.. |
| Water Treatment/Management | 1 | LS | $500,000 | $ 500,000 | Place holder for cost with no technical basis. NOT VERIFIED..... |
| Haul Road Construction (1 mile) | 6,000 | LF | $60 | $ 360,000 | Amec Foster Wheeler experience based on 12-inch thick ABC and supporting geotextile at 20-foot width. Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. |
| Excavation and Loading of Pond Ash for Truck Hauling | 10,382,000 | CY | $2.50 | $ 25,955,000 | Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. |
| Excavation and Loading of Subsurface Soils for Truck Hauling | 300,080 | CY | $2.50 | $ 750,200 | Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. |
| (On-Road) Hauling of Pond Ash and Impacted Soils for Off-site Landfill 15 miles | 10,767,935 | CY | $6.87 | $ 73,975,713 | Haul with on road dump trucks assumed with 17 cy max capacity. Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. Adjust for on road and distance using look up table. |
| (Off Road) Hauling of Pond Ash and Impacted Soils for On-site Landfill __ miles | | CY | $0.00 | $ - | Haul with off road dump trucks assumed with 17 cy max capacity. Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. Adjust for off road and distance using look up table. |
| Placement of Pond Ash and Impacted Soils In Landfill (Use placed volume) | 8,614,348 | CY | $1.31 | $ 11,284,796 | Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. |
| Truck Wash | 4 | EA | $150,000 | $ 600,000 | Truck wash necessary to clean tires and undercarriage of trucks for over-the-road hauling. Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. |
| Bridge Repair and Maintenance | 1 | LS | $500,000 | $ 500,000 | Placed holder estimate for potential bridge repair and maintenance cost. NOT VERIFIED. |
| Paved Haul Road Repair | 79,200 | LF | $120 | $ 9,504,000 | Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. |
| **SUBTOTAL ASH BASIN DEWATERING, EXCAVATION, HAULING AND PLACEMENT** | | | | $ 136,143,709 | |
| **LANDFILL & CLOSE IN PLACE COVER CONSTRUCTION** | | | | | |
| **Liner System Construction** | | | | | |
| Anchor Trench | 9,000 | LF | 6.00 | $ 54,000 | Unit Cost based on Amec Foster Wheeler experience and previous landfill cost estimates. |
| 8 oz/sy Non-Woven Geotextile | 166,667 | SY | 3.00 | $ 500,000 | Furnish and install geotextile as a cushion layer. Unit costs from Glover; costs typically include material, QC testing, and installation |
| Geosynthetic Clay Liner | 4,500,000 | SF | 0.73 | $ 3,285,000 | Unit Cost based on Amec Foster Wheeler experience and previous landfill cost estimates. |
| Textured 60-mil HDPE Geomembrane | 4,500,000 | SF | 0.64 | $ 2,880,000 | Unit Cost based on Amec Foster Wheeler experience and previous landfill cost estimates. |
| Geocomposite Drainage Layer | 4,500,000 | SF | $0.91 | $ 4,095,000 | Unit Cost based on Amec Foster Wheeler experience and previous landfill cost estimates. |

**Roxboro WAB Closure Option 2 - Closure by Removal (with Off-Site Landfill)**

**Closure Option Opinion of Probable Cost (ROM)**

**Duke Energy - Roxboro Steam Station**

**Person County, NC**

**1/8/2016**

| | Quantity | Unit | Unit Cost | Total Cost | Estimate Note |
|---|---|---|---|---|---|
| Protective Cover Fill | 166,667 | CY | $13.00 | $ 2,166,667 | Unit Cost based on Amec Foster Wheeler experience and previous landfill cost estimates. |
| Drainage Aggregate for Sump | 375 | CY | $67.00 | $ 25,125 | Unit Cost based on Amec Foster Wheeler experience and previous landfill cost estimates. |
| Fine Aggregate for Sump | 65 | CY | $55.00 | $ 3,575 | Unit Cost based on Amec Foster Wheeler experience and previous landfill cost estimates. |
| LCS Riser Pipes | 285 | LF | $190.00 | $ 54,150 | Unit Cost based on Amec Foster Wheeler experience and previous landfill cost estimates. |
| **Cover System Construction** | | | | | |
| Subgrade Preparation | 103 | Acres | $5,000.00 | $ 516,529 | Grade surface of subbase prior to installation of final cover system. Unit costs from construction contractor |
| Anchor Trench | 9,000 | LF | $6.00 | $ 54,000 | Furnish and install geotextile as a cushion layer. Unit costs from Glover; costs typically include material, QC testing, and installation |
| Geosynthetic Clay Liner (GCL) - Not required | 0 | SF | $0.73 | $ - | Furnish and install geotextile as a cushion layer. Unit costs from Glover; costs typically include material, QC testing, and installation |
| 8 oz/sy Non-Woven Geotextile | 500,000 | SY | 3.00 | $ 1,500,000 | Furnish and install geotextile as a cushion layer. Unit costs from Glover; costs typically include material, QC testing, and installation |
| Cover System Geosynthetics (40-mil LLDPE Geomembrane and Geocomposite Drainage Layer | 4,500,000 | SF | $1.45 | $ 6,525,000 | Unit Cost based on Amec Foster Wheeler experience and previous landfill cost estimates. |
| Cover System 18" Soil Cover | 250,000 | CY | $13.00 | $ 3,250,000 | Unit Cost based on Amec Foster Wheeler experience and previous landfill cost estimates. |
| Cover System Top Soil Placement | 84,000 | CY | $13.00 | $ 1,092,000 | Unit Cost based on Amec Foster Wheeler experience and previous landfill cost estimates. |
| **Close in Place Option Cover System Construction** | | | | | |
| Subgrade Preparation | 0 | Acres | $5,000.00 | $ - | Grade surface of subbase prior to installation of final cover system. Unit costs from construction contractor |
| Anchor Trench | 0 | LF | $6.00 | $ - | Furnish and install geotextile as a cushion layer. Unit costs from Glover; costs typically include material, QC testing, and installation |
| Geosynthetic Clay Liner (GCL) - Not required | 0 | SF | $0.73 | $ - | Furnish and install geotextile as a cushion layer. Unit costs from Glover; costs typically include material, QC testing, and installation |
| 8 oz/sy Non-Woven Geotextile | 0 | SY | 3.00 | $ - | Furnish and install geotextile as a cushion layer. Unit costs from Glover; costs typically include material, QC testing, and installation |
| Cover System Geosynthetics (40-mil LLDPE Geomembrane and Geocomposite Drainage Layer | 0 | SF | $1.45 | $ - | Unit Cost based on Amec Foster Wheeler experience and previous landfill cost estimates. |
| Cover System 18" Soil Cover | | CY | $13.00 | $ - | Unit Cost based on Amec Foster Wheeler experience and previous landfill cost estimates. |
| Cover System Top Soil Placement | | CY | $13.00 | $ - | Unit Cost based on Amec Foster Wheeler experience and previous landfill cost estimates. |
| **SUBTOTAL LANDFILL CONSTRUCTION** | | | | **$ 26,001,046** | |
| | | | | | |
| **SUBTOTAL FINAL CLOSURE CONSTRUCTION COST** | | | | **$ 183,433,255** | |
| **Estimate Mobilization Cost (5% of Final Closure Construction Cost)** | | | | **$ 9,171,663** | |
| **OTHER COST** | | | | | |
| **Design, Permitting and CQA** | | | | | |
| Closure Design/Engineering/Permitting (10% of Final Closure Construction Costs) | 1 | LS | $ 18,343,325 | $ 18,343,325 | Amec Foster Wheeler experience from previous projects |
| Construction Quality Assurance (CQA) (12% of Final Closure Construction Costs) | 1 | LS | $ 22,011,991 | $ 22,011,991 | Amec Foster Wheeler experience from previous projects |
| **Subtotal Design, Permitting and CQA** | | | | **$ 40,355,316** | |
| **Post Closure Operations and Maintenance (analysis based on 30 year duration)** | | | | | |
| Close in Place (Capped) Area Maintenance ( 0 acres) | 0 | YR | $ - | $ - | Estimate at $1700/acre/year of capped area. |
| Close in Place (Capped) Area Monitoring | 0 | YR | $ 58,000 | $ - | Amec Foster Wheeler experience from previous projects |
| Landfill Area Maintenance (103 acres) | 30 | YR | $ 175,100 | $ 5,253,000 | Estimate at $1700/acre/year of lined landfill area. |
| Landfill Area Monitoring | 30 | YR | $ 58,000 | $ 1,740,000 | Amec Foster Wheeler experience from previous projects |
| **Subtotal Post Closure Operations and Maintenance** | | | | **$ 6,993,000** | |
| **Additional Costs** | | | | | |
| Contingency (15% of Final Closure Construction Costs) | 1 | LS | $ 27,514,988 | $ 27,514,988 | Amec Foster Wheeler experience from previous projects |
| **Subtotal Additional Costs** | | | | **$ 27,514,988** | |
| | | | | | |
| **TOTAL OPINION OF PROBABLE CLOSURE COST** | | | | **$ 267,468,222** | Rough Order of Magniture Cost Estimate |
| **OPINION OF PROBABLE CLOSURE COST PER CY** | | | | **$ 25.76** | Based on Volume Placed in landfill |
| **OPINION OF PROBABLE CLOSURE COST PER TON** | | | | **$ 21.47** | Based on Moist Unit Weight of 1.2 Tons/CY |
| **OPINION OF PROBABLE CLOSURE COST PER ACRE** | | | | **$ 1,438,001** | Based on Estimated Closue Area |

**ESTIMATED QUANTITIES**

| Description | Est Quantity | Units |
|---|---|---|
| Estimated Landfill Property Area: | 400 | Acres |
| Estimated Landfill Development Area (including buffer and borrow area): | 250 | Acres |
| Estimated Lined Landfill Area: | 103 | Acres |
| Estimated West Ash Basin Closure Area: | 186 | Acres |
| Estimated WAB Restoration Area (after ash removal): | 186 | Acres |
| Estimated Ash Material Removed/Hauled Volume: | 10,382,000 | CY |
| Estimated Ash Material Removed/Hauled Moist Wt: | 12,458,400 | Tons (bsed on 1.2 Tons/CY Moist Unit Wt) |
| Estimated Contaminated Soil Removed/Hauled Volume (WAB): | 300,080 | CY |
| Estimated Contaminated Soil Removed/Hauled Volume (Disch Channel): | 85,855 | CY |
| Estimated Contaminated Soil Removed/Hauled Moist Wt: | 578,903 | Tons (based on 1.5 Tons/CY Moist Unit Wt) |
| Total Estimated Ash and Contaminated Soil Removed/Hauled Volume: | 10,767,935 | CY |
| Total Estimated Ash and Contaminated Soil Removed/Hauled Moist Wt: | 13,037,303 | Tons (based on Moist Unit Wt ) |
| Total Estimated Ash and Contaminated Soil Placed in Landfill Volume: | 8,614,348 | Tons (based on 0.8 x Volume Hauled ) |

**Estimate Notes:**

1. This estimate is represented as Rough Order of Magnitude (ROM).

**Roxboro WAB Closure Option 3 - Closure by Removal (with EAB Landfill Phases 7-9)**

**Closure Option Opinion of Probable Cost (ROM)**

**Duke Energy - Roxboro Steam Station**

**Person County, NC**

**1/8/2016**

| | Quantity | Unit | Unit Cost | Total Cost | Estimate Note |
|---|---|---|---|---|---|
| **PROPERTY ACQUISTION** | | | | | |
| Property Acquition Cost | 0 | Acres | $3,000 | $ - | Best estimate of property values in area from review of tax values and for sale listing for large tracts in Person County. NOT VERIFIED. |
| **SUBTOTAL PROPERTY ACQUISTION** | | | | $ - | |
| **GENERAL** | | | | | |
| Mobilization | 1 | LS | | $ - | Estimate at 5% of Final Closure Construction Cost (see below) |
| Surveying | 186 | Acres | $ 2,000 | $ 372,000 | |
| Abandon WAB Discharge Outlet Structures | 2 | EA | $ 150,000 | $ 300,000 | Estimate at $150k/riser |
| **SUBTOTALGENERAL** | | | | $ 672,000 | |
| **EROSION/SEDIMENT CONTROL AND STORMWATER MANAGEMENT** | | | | | |
| West Ash Basin Sediment Control and Stormwater Management | 186 | Acres | $14,000.00 | $ 2,604,000 | Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. Includes silt fence, wattles, surface water diversions, sediment basins, temporary seeding and permanent seeding. |
| Landfill Area Sediment Control and Stormwater Management | 213 | Acres | $14,000.00 | $ 2,982,000 | Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. Includes silt fence, wattles, surface water diversions, sediment basins, temporary seeding and permanent seeding. |
| Bridge or Embankment (with culverts) for discharge channel crossing | 1 | LS | $500,000 | $ 500,000 | Place holder for cost with no technical basis. NOT VERIFIED..... |
| Project Specific Stormewater Management Requirements | | Acres | | $ - | |
| | | | | $ - | |
| | | | | $ - | |
| | | | | $ - | |
| | | | | $ - | |
| **SUBTOTAL EROSION/SEDIMENT CONTROL AND STORMWATER MANAGEMENT** | | | | $ 6,086,000 | |
| **EARTHWORK** | | | | | |
| **Ash Basin Earthwork** | | | | | |
| Construction Entrance | 1000 | LF | $65 | $ 65,000 | Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. |
| Clearing and Grubbing | 5 | Acres | $5,000 | $ 25,000 | Clear and remove vegetation including trees, brush, schrubs. Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. Increased to $5000/acre from review by NWH. |
| Topsoil Stripping | 5 | Acres | $4,000 | $ 20,000 | Strip topsoil to a minimum 6-inch depth and place in stockpile. Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. Incresed to $4000/acre from review by NWH. |
| Earthwork Cut to Waste | 0 | CY | $6.25 | $ - | Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. |
| Earthwork Cut to Fill | 10,000 | CY | $6.25 | $ 62,500 | Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. |
| Soil Material (18 inches, minimum, source material on-site ) | | CY | $13 | $ - | Load, haul, place, and grade common borrow soil material. Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. |
| Topsoil Material; if required (6-inch thick un-compacted fill, source material off-site) | | CY | $13 | $ - | Load, haul, place, and grade topsoil material. Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. |
| **Landfill Earthwork** | | | | | |
| Construction Entrance | 1000 | LF | $65 | $ 65,000 | Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. |
| Clearing and Grubbing | 200 | Acres | $5,000 | $ 1,000,000 | Clear and remove vegetation including trees, brush, schrubs. Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. Increased to $5000/acre from review by NWH. |
| Topsoil Stripping | 200 | Acres | $4,000 | $ 800,000 | Strip topsoil to a minimum 6-inch depth and place in stockpile. Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. Incresed to $4000/acre from review by NWH. |
| Earthwork cut to fill | 1,700,000 | CY | $5.40 | $ 9,180,000 | Grade the site following ash material removal to promote storm water management; grading will be performed to balance cut/fill related to remaining dike/berm soil materials. Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. |
| Stockpiling of Excavation Soils | 2,000,000 | CY | $0.50 | $ 1,000,000 | Grade the site following ash material removal to promote storm water management; grading will be performed to balance cut/fill related to remaining dike/berm soil materials. Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. |
| Perimeter Grading | 50000 | CY | $5.40 | $ 270,000 | Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. |
| Soil Material (18 inches, minimum, source material on-site ) | | CY | $13 | $ - | Load, haul, place, and grade common borrow soil material. Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. |
| Topsoil Material; if required (6-inch thick un-compacted fill, source material off-site) | | CY | $13 | $ - | Load, haul, place, and grade topsoil material. Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. |
| **SUBTOTAL EARTHWORK** | | | | $ 12,487,500 | |
| **ASH BASIN DEWATERING, EXCAVATION, HAULING AND PLACEMENT** | | | | | |
| Temporary Dewatering for WAB Free Water (Estimate 162 million gallons) | 500 | Hours | $750.00 | $ 375,000 | Estimate based on Roxboro West Ash Pond H&H Issuses Improvement Plan, Dewatering/Pumping Plan. Assume drawdown limited to 1 foot/day will require pumping capacity of about 7500 GPM. Estimated time required for initial drawdown: 162,000,000 Gal/7500 GPM x 60 = 360 hours. Use 500 hours for estimating purposes to provide est contingency. Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. |
| Temporary Dewatering for WAB base inflow and stormwater during construction (assume duration of construction to be 5.5 years) | 8,030 | Hours | $750.00 | $ 6,022,500 | Estimate pumping required intermittently for duration of excavation to handle base flow and stormwater inflow. For estimating purposes, assume that pumping will be required for at least 4 hours/day for duration of construction. 4 hr/day x 365 days/yr x 5.5 year construction duration = 8030 hrs. Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates.. |
| Temporary Dewatering for WAB Discharge Channel Free Water (Estimate 7.5 million gallons) | 100 | Hours | $750.00 | $ 75,000 | Assume drawdown with pumping capacity of 2000 GPM. Estimated time required for initial drawdown: 7,500,000 Gal//2000 GPM x 60 = 62.5 hours. Use 100 hours for estimating purposes. Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. No adjustment for pumping capacity recommended for pumping unit cost. |
| Temporary Dewatering for WAB base inflow and stormwater during construction (assume duration of construction to be 6 months) | 730 | Hours | $750.00 | $ 547,500 | Estimate pumping required intermittently for duration of excavation to handle base flow and stormwater inflow. For estimating purposes, assume that pumping will be required for at least 4 housr/day for duration of construction. 4 hr/day x 365 days/yr x 0.5 year construction duration = 730 hrs. Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates.. |
| Water Treatment/Management | 1 | LS | $500,000 | $ 500,000 | Place holder for cost with no technical basis. NOT VERIFIED..... |
| Haul Road Construction (1 mile) | 6,000 | LF | $60 | $ 360,000 | Amec Foster Wheeler experience based on 12-inch thick ABC and supporting geotextile at 20-foot width. Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. |
| Excavation and Loading of Pond Ash for Truck Hauling | 10,382,000 | CY | $2.50 | $ 25,955,000 | Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. |
| Excavation and Loading of Subsurface Soils for Truck Hauling | 300,080 | CY | $2.50 | $ 750,200 | Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. |
| (On-Road) Hauling of Pond Ash and Impacted Soils for Off-site Landfill __ miles | | CY | $6.50 | $ - | Haul with on road dump trucks assumed with 17 cy max capacity. Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. Adjust for on road and distance using look up table. |
| (Off Road) Hauling of Pond Ash and Impacted Soils for On-site Landfill 1.2 miles | 10,767,935 | CY | $2.46 | $ 26,489,120 | Haul with off road dump trucks assumed with 17 cy max capacity. Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. Adjust for off road and distance using look up table. |
| Placement of Pond Ash and Impacted Soils In Landfill (Use placed volume) | 8,614,348 | CY | $1.31 | $ 11,284,796 | Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. |
| Truck Wash | 4 | EA | $150,000 | $ 600,000 | Truck wash necessary to clean tires and undercarriage of trucks for over-the-road hauling. Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. |
| Bridge Repair and Maintenance | 0 | LS | $500,000 | $ - | Placed holder estimate for potential bridge repair and maintenance cost. NOT VERIFIED. |
| Paved Haul Road Repair | 1,000 | LF | $120 | $ 120,000 | Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. |
| **SUBTOTAL ASH BASIN DEWATERING, EXCAVATION, HAULING AND PLACEMENT** | | | | $ 73,079,116 | |
| **LANDFILL & CLOSE IN PLACE COVER CONSTRUCTION** | | | | | |
| **Liner System Construction** | | | | | |
| Anchor Trench | 9,000 | LF | 6.00 | $ 54,000 | Unit Cost based on Amec Foster Wheeler experience and previous landfill cost estimates. |
| 8 oz/sy Non-Woven Geotextile | 416,240 | SY | 3.00 | $ 1,248,720 | Furnish and install geotextile as a cushion layer. Unit costs from Glover; costs typically include material, QC testing, and installation |
| Geosynthetic Clay Liner | 3,746,160 | SF | 0.73 | $ 2,734,697 | Unit Cost based on Amec Foster Wheeler experience and previous landfill cost estimates. |
| Textured 60-mil HDPE Geomembrane | 3,746,160 | SF | 0.64 | $ 2,397,542 | Unit Cost based on Amec Foster Wheeler experience and previous landfill cost estimates. |
| Geocomposite Drainage Layer | 3,746,160 | SF | $0.91 | $ 3,409,006 | Unit Cost based on Amec Foster Wheeler experience and previous landfill cost estimates. |
| Protective Cover Fill | 138,747 | CY | $13.00 | $ 1,803,707 | Unit Cost based on Amec Foster Wheeler experience and previous landfill cost estimates. |

**Roxboro WAB Closure Option 3 - Closure by Removal (with EAB Landfill Phases 7-9)**

**Closure Option Opinion of Probable Cost (ROM)**

**Duke Energy - Roxboro Steam Station**

**Person County, NC**

**1/8/2016**

| | Quantity | Unit | Unit Cost | Total Cost | Estimate Note |
|---|---|---|---|---|---|
| Drainage Aggregate for Sump | 375 | CY | $67.00 | $ 25,125 | Unit Cost based on Amec Foster Wheeler experience and previous landfill cost estimates. |
| Fine Aggregate for Sump | 65 | CY | $55.00 | $ 3,575 | Unit Cost based on Amec Foster Wheeler experience and previous landfill cost estimates. |
| LCS Riser Pipes | 285 | LF | $190.00 | $ 54,150 | Unit Cost based on Amec Foster Wheeler experience and previous landfill cost estimates. |
| **Cover System Construction** | | | | | |
| Subgrade Preparation | 86 | Acres | $5,000.00 | $ 430,000 | Grade surface of subbase prior to installation of final cover system. Unit costs from construction contractor |
| Anchor Trench | 9,000 | LF | $6.00 | $ 54,000 | Furnish and install geotextile as a cushion layer. Unit costs from Glover; costs typically include material, QC testing, and installation |
| Geosynthetic Clay Liner (GCL) - Not required | 0 | SF | $0.73 | $ - | Furnish and install geotextile as a cushion layer. Unit costs from Glover; costs typically include material, QC testing, and installation |
| 8 oz/sy Non-Woven Geotextile | 416,240 | SY | 3.00 | $ 1,248,720 | Furnish and install geotextile as a cushion layer. Unit costs from Glover; costs typically include material, QC testing, and installation |
| Cover System Geosynthetics (40-mil LLDPE Geomembrane and Geocomposite Drainage Layer | 3,746,160 | SF | $1.45 | $ 5,431,932 | Unit Cost based on Amec Foster Wheeler experience and previous landfill cost estimates. |
| Cover System 18" Soil Cover | 208,120 | CY | $13.00 | $ 2,705,560 | Unit Cost based on Amec Foster Wheeler experience and previous landfill cost estimates. |
| Cover System Top Soil Placement | 69,373 | CY | $13.00 | $ 901,853 | Unit Cost based on Amec Foster Wheeler experience and previous landfill cost estimates. |
| **Close in Place Option Cover System Construction** | | | | | |
| Subgrade Preparation | | Acres | $5,000.00 | $ - | Grade surface of subbase prior to installation of final cover system. Unit costs from construction contractor |
| Anchor Trench | | LF | $6.00 | $ - | Furnish and install geotextile as a cushion layer. Unit costs from Glover; costs typically include material, QC testing, and installation |
| Geosynthetic Clay Liner (GCL) - Not required | | SF | $0.73 | $ - | Furnish and install geotextile as a cushion layer. Unit costs from Glover; costs typically include material, QC testing, and installation |
| 8 oz/sy Non-Woven Geotextile | | SY | 3.00 | $ - | Furnish and install geotextile as a cushion layer. Unit costs from Glover; costs typically include material, QC testing, and installation |
| Cover System Geosynthetics (40-mil LLDPE Geomembrane and Geocomposite Drainage Layer | | SF | $1.45 | $ - | Unit Cost based on Amec Foster Wheeler experience and previous landfill cost estimates. |
| Cover System 18" Soil Cover | | CY | $13.00 | $ - | Unit Cost based on Amec Foster Wheeler experience and previous landfill cost estimates. |
| Cover System Top Soil Placement | | CY | $13.00 | $ - | Unit Cost based on Amec Foster Wheeler experience and previous landfill cost estimates. |
| **SUBTOTAL LANDFILL CONSTRUCTION** | | | | **$ 22,502,587** | |
| | | | | | |
| **SUBTOTAL FINAL CLOSURE CONSTRUCTION COST** | | | | **$ 114,827,203** | |
| **Estimate Mobilization Cost (5% of Final Closure Construction Cost)** | | | | **$ 5,741,360** | |
| **OTHER COST** | | | | | |
| **Design, Permitting and CQA** | | | | | |
| Closure Design/Engineering/Permitting (10% of Final Closure Construction Costs) | 1 | LS | $ 11,482,720 | $ 11,482,720 | Amec Foster Wheeler experience from previous projects |
| Construction Quality Assurance (CQA) (12% of Final Closure Construction Costs) | 1 | LS | $ 13,779,264 | $ 13,779,264 | Amec Foster Wheeler experience from previous projects |
| **Subtotal Design, Permitting and CQA** | | | | **$ 25,261,985** | |
| **Post Closure Operations and Maintenance (analysis based on 30 year duration)** | | | | | |
| Close in Place (Capped) Area Maintenance ( 0 acres) | 0 | YR | $ - | $ - | Estimate at $1700/acre/year of capped area. |
| Close in Place (Capped) Area Monitoring | 0 | YR | $ 58,000 | $ - | Amec Foster Wheeler experience from previous projects |
| Landfill Area Maintenance (86 acres) | 30 | YR | $ 146,200 | $ 4,386,000 | Estimate at $1700/acre/year of lined landfill area. |
| Landfill Area Monitoring | 30 | YR | $ 58,000 | $ 1,740,000 | Amec Foster Wheeler experience from previous projects |
| **Subtotal Post Closure Operations and Maintenance** | | | | **$ 6,126,000** | |
| **Additional Costs** | | | | | |
| Contingency (15% of Final Closure Construction Costs) | 1 | LS | $ 17,224,080 | $ 17,224,080 | Amec Foster Wheeler experience from previous projects |
| **Subtotal Additional Costs** | | | | **$ 17,224,080** | |
| | | | | | |
| **TOTAL OPINION OF PROBABLE CLOSURE COST** | | | | **$ 169,180,628** | Rough Order of Magniture Cost Estimate |
| **OPINION OF PROBABLE CLOSURE COST PER CY** | | | | **$ 16.30** | Based on Volume Placed in landfill |
| **OPINION OF PROBABLE CLOSURE COST PER TON** | | | | **$ 13.58** | Based on Moist Unit Weight of 1.2 Tons/CY |
| **OPINION OF PROBABLE CLOSURE COST PER ACRE** | | | | **$ 909,573** | Based on Estimated Closue Area |

**ESTIMATED QUANTITIES**

| Description | Est Quantity | Units |
|---|---|---|
| Estimated Landfill Property Area: | 0 | Acres |
| Estimated Landfill Development Area (including buffer and borrow area): | 213 | Acres |
| Estimated Lined Landfill Area: | 86 | Acres |
| Estimated West Ash Basin Closure Area: | 186 | Acres |
| Estimated WAB Restoration Area (after ash removal): | 186 | Acres |
| Estimated Ash Material Removed/Hauled Volume: | 10,382,000 | CY |
| Estimated Ash Material Removed/Hauled Moist Wt: | 12,458,400 | Tons (bsed on 1.2 Tons/CY Moist Unit Wt) |
| Estimated Contaminated Soil Removed/Hauled Volume (WAB): | 300,080 | CY |
| Estimated Contaminated Soil Removed/Hauled Volume (Disch Channel): | 85,855 | CY |
| Estimated Contaminated Soil Removed/Hauled Moist Wt: | 578,903 | Tons (based on 1.5 Tons/CY Moist Unit Wt) |
| Total Estimated Ash and Contaminated Soil Removed/Hauled Volume: | 10,767,935 | CY |
| Total Estimated Ash and Contaminated Soil Removed/Hauled Moist Wt: | 13,037,303 | Tons (based on Moist Unit Wt ) |
| Total Estimated Ash and Contaminated Soil Placed in Landfill Volume: | 8,614,348 | Tons (based on 0.8 x Volume Hauled ) |

**Estimate Notes:**

1. This estimate is represented as Rough Order of Magnitude (ROM).

## Roxboro WAB Closure Option 4 - Close in Place Hybrid (CAP Concept)

## Closure Option Opinion of Probable Cost (ROM)

## Duke Energy - Roxboro Steam Station

## Person County, NC

## 1/8/2016

| | Quantity | Unit | Unit Cost | Total Cost | Estimate Note |
|---|---|---|---|---|---|
| **PROPERTY ACQUISTION** | | | | | |
| Property Acquition Cost | 0 | Acres | $3,000 | $ - | Best estimate of property values in area from review of tax values and for sale listing for large tracts in Person County. NOT VERIFIED. |
| **SUBTOTAL PROPERTY ACQUISTION** | | | | $ - | |
| **GENERAL** | | | | | |
| Mobilization | 1 | LS | | $ - | Estimate at 5% of Final Closure Construction Cost (see below) |
| Surveying | 186 | Acres | $ 2,000 | $ 372,000 | |
| Abandon WAB Discharge Outlet Structures | 2 | EA | $ 150,000 | $ 300,000 | Estimate at $150k/riser |
| **SUBTOTALGENERAL** | | | | $ 672,000 | |
| **EROSION/SEDIMENT CONTROL AND STORMWATER MANAGEMENT** | | | | | |
| West Ash Basin Sediment Control and Stormwater Management | 186 | Acres | $14,000.00 | $ 2,604,000 | Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. Includes silt fence, wattles, surface water diversions, sediment basins, temporary seeding and permanent seeding. |
| Landfill Area Sediment Control and Stormwater Management | 0 | Acres | $14,000.00 | $ - | Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. Includes silt fence, wattles, surface water diversions, sediment basins, temporary seeding and permanent seeding. |
| Bridge or Embankment (with culverts) for discharge channel crossing | 1 | LS | $500,000 | $ 500,000 | Place holder for cost with no technical basis. NOT VERIFIED..... |
| Breaching WAB Main Dam | 1 | LS | $1,000,000 | $ 1,000,000 | Place holder for cost with no technical basis. NOT VERIFIED..... |
| Permanent Drainage and Surface Stabilization Measures | 186 | Acres | $14,000 | $ 2,604,000 | Place holder for cost with no technical basis. NOT VERIFIED..... |
| | | | | $ - | |
| | | | | $ - | |
| | | | | $ - | |
| **SUBTOTAL EROSION/SEDIMENT CONTROL AND STORMWATER MANAGEMENT** | | | | $ 6,708,000 | |
| **EARTHWORK** | | | | | |
| **Ash Basin Earthwork** | | | | | |
| Construction Entrance | 1000 | LF | $65 | $ 65,000 | Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. |
| Clearing and Grubbing | 5 | Acres | $5,000 | $ 25,000 | Clear and remove vegetation including trees, brush, schrubs. Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. Increased to $5000/acre from review by NWH. |
| Topsoil Stripping | 5 | Acres | $4,000 | $ 20,000 | Strip topsoil to a minimum 6-inch depth and place in stockpile. Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. Incresed to $4000/acre from review by NWH. |
| Earthwork Cut to Waste | 0 | CY | $6.25 | $ - | Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. |
| Earthwork Cut to Fill (for grading and placement for drainage channel) | 534,539 | CY | $6.25 | $ 3,340,869 | Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. |
| Soil Material (fill required for drainage channel) | 534,539 | CY | $13 | $ 6,949,007 | Load, haul, place, and grade common borrow soil material. Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. |
| Topsoil Material; if required (6-inch thick un-compacted fill, source material off-site) | | CY | $13 | $ - | Load, haul, place, and grade topsoil material. Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. |
| **Landfill Earthwork** | | | | | |
| Construction Entrance | 0 | LF | $65 | $ - | Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. |
| Clearing and Grubbing | 0 | Acres | $5,000 | $ - | Clear and remove vegetation including trees, brush, schrubs. Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. Increased to $5000/acre from review by NWH. |
| Topsoil Stripping | 0 | Acres | $4,000 | $ - | Strip topsoil to a minimum 6-inch depth and place in stockpile. Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. Incresed to $4000/acre from review by NWH. |
| Earthwork cut to fill | 0 | CY | $5.40 | $ - | Grade the site following ash material removal to promote storm water management; grading will be performed to balance cut/fill related to remaining dike/berm soil materials. Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. |
| Stockpiling of Excavation Soils | 0 | CY | $0.50 | $ - | Grade the site following ash material removal to promote storm water management; grading will be performed to balance cut/fill related to remaining dike/berm soil materials. Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. |
| Perimeter Grading | 0 | CY | $5.40 | $ - | Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. |
| Soil Material (18 inches, minimum, source material on-site ) | | CY | $13 | $ - | Load, haul, place, and grade common borrow soil material. Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. |
| Topsoil Material; if required (6-inch thick un-compacted fill, source material off-site) | | CY | $13 | $ - | Load, haul, place, and grade topsoil material. Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. |
| **SUBTOTAL EARTHWORK** | | | | $ 10,399,876 | |
| **ASH BASIN DEWATERING, EXCAVATION, HAULING AND PLACEMENT** | | | | | |
| Temporary Dewatering for WAB Free Water (Estimate 162 million gallons) | 500 | Hours | $750.00 | $ 375,000 | Estimate based on Roxboro West Ash Pond H&H Issuses Improvement Plan, Dewatering/Pumping Plan. Assume drawdown limited to 1 foot/day will require pumping capacity of about 7500 GPM. Estimated time required for initial drawdown: 162,000,000 Gal/7500 GPM x 60 = 360 hours. Use 500 hours for estimating purposes to provide est contingency. Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. |
| Temporary Dewatering for WAB base inflow and stormwater during construction (assume duration of construction to be 2.7 years) | 3,942 | Hours | $750.00 | $ 2,956,500 | Estimate pumping required intermittently for duration of excavation to handle base flow and stormwater inflow. For estimating purposes, assume that pumping will be required for at least 4 hours/day for duration of construction. 4 hr/day x 365 days/yr x2.7 year construction duration = 3942 hrs. Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates.. |
| Temporary Dewatering for WAB Discharge Channel Free Water (Estimate 7.5 million gallons) | 100 | Hours | $750.00 | $ 75,000 | Assume drawdown with pumping capacity of 2000 GPM. Estimated time required for initial drawdown: 7,500,000 Gal//2000 GPM x 60 = 62.5 hours. Use 100 hours for estimating purposes. Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. No adjustment for pumping capacity recommended for pumping unit cost. |
| Temporary Dewatering for WAB base inflow and stormwater during construction (assume duration of construction to be 6 months) | 730 | Hours | $750.00 | $ 547,500 | Estimate pumping required intermittently for duration of excavation to handle base flow and stormwater inflow. For estimating purposes, assume that pumping will be required for at least 4 housr/day for duration of construction. 4 hr/day x 365 days/yr x 0.5 year construction duration = 730 hrs. Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates.. |
| Water Treatment/Management | 1 | LS | $500,000 | $ 500,000 | Place holder for cost with no technical basis. NOT VERIFIED..... |
| Haul Road Construction (1 mile) | 6,000 | LF | $60 | $ 360,000 | Amec Foster Wheeler experience based on 12-inch thick ABC and supporting geotextile at 20-foot width. Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. |
| Excavation and Loading of Pond Ash for Truck Hauling | 5,140,645 | CY | $2.50 | $ 12,851,613 | Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. |
| Excavation and Loading of Subsurface Soils for Truck Hauling | 261,708 | CY | $2.50 | $ 654,270 | Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. |
| (On-Road) Hauling of Pond Ash and Impacted Soils for Off-site Landfill __ miles | | CY | $6.50 | $ - | Haul with on road dump trucks assumed with 17 cy max capacity. Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. Adjust for on road and distance using look up table. |
| (Off Road) Hauling of Pond Ash and Impacted Soils for On-site Landfill 0.5 miles | 5,402,353 | CY | $2.05 | $ 11,074,824 | Haul with off road dump trucks assumed with 17 cy max capacity. Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. Adjust for off road and distance using look up table. Use rate of $2.05/cy min.. |
| Placement of Pond Ash and Impacted Soils In Landfill (Use placed volume) | 4,321,882 | CY | $1.31 | $ 5,661,666 | Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. |
| Truck Wash | 4 | EA | $150,000 | $ 600,000 | Truck wash necessary to clean tires and undercarriage of trucks for over-the-road hauling. Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. |
| Bridge Repair and Maintenance | 0 | LS | $500,000 | $ - | Placed holder estimate for potential bridge repair and maintenance cost. NOT VERIFIED. |
| Paved Haul Road Repair | 1,000 | LF | $120 | $ 120,000 | Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. |
| **SUBTOTAL ASH BASIN DEWATERING, EXCAVATION, HAULING AND PLACEMENT** | | | | $ 35,776,372 | |
| **LANDFILL & CLOSE IN PLACE COVER CONSTRUCTION** | | | | | |
| **Liner System Construction** | | | | | |
| Anchor Trench | 0 | LF | 6.00 | $ - | Unit Cost based on Amec Foster Wheeler experience and previous landfill cost estimates. |
| Geosynthetic Clay Liner | 0 | SF | 0.70 | $ - | Unit Cost based on Amec Foster Wheeler experience and previous landfill cost estimates. |
| Textured 60-mil HDPE Geomembrane | 0 | SF | 0.58 | $ - | Unit Cost based on Amec Foster Wheeler experience and previous landfill cost estimates. |
| Geocomposite Drainage Layer | 0 | SF | $1.11 | $ - | Unit Cost based on Amec Foster Wheeler experience and previous landfill cost estimates. |
| Protective Cover Fill | 0 | CY | $13.00 | $ - | Unit Cost based on Amec Foster Wheeler experience and previous landfill cost estimates. |
| Drainage Aggregate for Sump | 0 | CY | $67.00 | $ - | Unit Cost based on Amec Foster Wheeler experience and previous landfill cost estimates. |

## Roxboro WAB Closure Option 4 - Close in Place Hybrid (CAP Concept)

## Closure Option Opinion of Probable Cost (ROM)

## Duke Energy - Roxboro Steam Station

## Person County, NC

## 1/8/2016

| | Quantity | Unit | Unit Cost | Total Cost | Estimate Note |
|---|---|---|---|---|---|
| Fine Aggregate for Sump | 0 | CY | $55.00 | $ - | Unit Cost based on Amec Foster Wheeler experience and previous landfill cost estimates. |
| LCS Riser Pipes | 0 | LF | $190.00 | $ - | Unit Cost based on Amec Foster Wheeler experience and previous landfill cost estimates. |
| **Cover System Construction** | | | | | |
| Subgrade Preparation | | Acres | $5,000.00 | $ - | Grade surface of subbase prior to installation of final cover system. Unit costs from construction contractor |
| Anchor Trench | | LF | $6.00 | $ - | Furnish and install geotextile as a cushion layer. Unit costs from Glover; costs typically include material, QC testing, and installation |
| Geosynthetic Clay Liner (GCL) - Not required | | SF | $0.73 | $ - | Furnish and install geotextile as a cushion layer. Unit costs from Glover; costs typically include material, QC testing, and installation |
| 8 oz/sy Non-Woven Geotextile | | SY | 3.00 | $ - | Furnish and install geotextile as a cushion layer. Unit costs from Glover; costs typically include material, QC testing, and installation |
| Cover System Geosynthetics (40-mil LLDPE Geomembrane and Geocomposite Drainage Layer | | SF | $1.45 | $ - | Unit Cost based on Amec Foster Wheeler experience and previous landfill cost estimates. |
| Cover System Geosynthetics | 0 | SF | $1.14 | $ - | Unit Cost based on Amec Foster Wheeler experience and previous landfill cost estimates. |
| Cover System 18" Soil Cover | 0 | CY | $13.00 | $ - | Unit Cost based on Amec Foster Wheeler experience and previous landfill cost estimates. |
| Cover System Top Soil Placement | 0 | CY | $13.00 | $ - | Unit Cost based on Amec Foster Wheeler experience and previous landfill cost estimates. |
| **Close in Place Option Cover System Construction** | | | | | |
| Subgrade Preparation | 77 | Acres | $5,000.00 | $ 385,000 | Grade surface of subbase prior to installation of final cover system. Unit costs from construction contractor |
| Anchor Trench | 9,000 | LF | $6.00 | $ 54,000 | Furnish and install geotextile as a cushion layer. Unit costs from Glover; costs typically include material, QC testing, and installation |
| Geosynthetic Clay Liner (GCL) - Not required | 0 | SF | $0.73 | $ - | Furnish and install geotextile as a cushion layer. Unit costs from Glover; costs typically include material, QC testing, and installation |
| 8 oz/sy Non-Woven Geotextile | 372,680 | SY | 3.00 | $ 1,118,040 | Furnish and install geotextile as a cushion layer. Unit costs from Glover; costs typically include material, QC testing, and installation |
| Cover System Geosynthetics (40-mil LLDPE Geomembrane and Geocomposite Drainage Layer | 3,354,120 | SF | $1.45 | $ 4,863,474 | Unit Cost based on Amec Foster Wheeler experience and previous landfill cost estimates. |
| Cover System 18" Soil Cover | 186,340 | CY | $13.00 | $ 2,422,420 | Unit Cost based on Amec Foster Wheeler experience and previous landfill cost estimates. |
| Cover System Top Soil Placement | 62,113 | CY | $13.00 | $ 807,473 | Unit Cost based on Amec Foster Wheeler experience and previous landfill cost estimates. |
| **SUBTOTAL LANDFILL & COVER SYSTEM CONSTRUCTION** | | | | **$ 9,650,407** | |
| | | | | | |
| **SUBTOTAL FINAL CLOSURE CONSTRUCTION COST** | | | | **$ 63,206,655** | |
| **Estimate Mobilization Cost (5% of Final Closure Construction Cost)** | | | | **$ 3,160,333** | |
| **OTHER COST** | | | | | |
| **Design, Permitting and CQA** | | | | | |
| Closure Design/Engineering/Permitting (10% of Final Closure Construction Costs) | 1 | LS | $ 6,320,666 | $ 6,320,666 | Amec Foster Wheeler experience from previous projects |
| Construction Quality Assurance (CQA) (12% of Final Closure Construction Costs) | 1 | LS | $ 7,584,799 | $ 7,584,799 | Amec Foster Wheeler experience from previous projects |
| **Subtotal Design, Permitting and CQA** | | | | **$ 13,905,464** | |
| **Post Closure Operations and Maintenance (analysis based on 30 year duration)** | | | | | |
| Close in Place (Capped) Area Maintenance (77 acres) | 30 | YR | $ 130,900 | $ 3,927,000 | Estimate at $1700/acre/year of capped area. |
| Close in Place (Capped) Area Monitoring | 30 | YR | $ 58,000 | $ 1,740,000 | Amec Foster Wheeler experience from previous projects |
| Landfill Area Maintenance (0 acres) | 0 | YR | $ - | $ - | Estimate at $1700/acre/year of lined landfill area. |
| Landfill Area Monitoring | 0 | YR | $ 58,000 | $ - | Amec Foster Wheeler experience from previous projects |
| **Subtotal Post Closure Operations and Maintenance** | | | | **$ 5,667,000** | |
| **Additional Costs** | | | | | |
| Contingency (15% of Final Closure Construction Costs) | 1 | LS | $ 9,480,998 | $ 9,480,998 | Amec Foster Wheeler experience from previous projects |
| **Subtotal Additional Costs** | | | | **$ 9,480,998** | |
| | | | | | |
| **TOTAL OPINION OF PROBABLE CLOSURE COST** | | | | **$ 95,420,450** | Rough Order of Magniture Cost Estimate |
| **OPINION OF PROBABLE CLOSURE COST PER CY** | | | | **$ 18.56** | Based on Volume Placed in landfill |
| **OPINION OF PROBABLE CLOSURE COST PER TON** | | | | **$ 15.47** | Based on Moist Unit Weight of 1.2 Tons/CY |
| **OPINION OF PROBABLE CLOSURE COST PER ACRE** | | | | **$ 513,013** | Based on Estimated Closue Area |

**ESTIMATED QUANTITIES**

| Description | Est Quantity | Units |
|---|---|---|
| Estimated Landfill Property Area: | 0 | Acres |
| Estimated Landfill Development Area (including buffer and borrow area): | 0 | Acres |
| Estimated Lined Landfill Area: | 0 | Acres |
| Estimated West Ash Basin Closure Area: | 186 | Acres |
| Estimated WAB Restoration Area (after ash removal): | 109 | Acres |
| Estimated Close in Place Area: | 77 | Acres |
| Estimated Ash Material Removed/Hauled Volume: | 5,140,645 | CY |
| Estimated Ash Material Removed/Hauled Moist Wt: | 6,168,774 | Tons (bsed on 1.2 Tons/CY Moist Unit Wt) |
| Estimated Contaminated Soil Removed/Hauled Volume (WAB): | 175,853 | CY |
| Estimated Contaminated Soil Removed/Hauled Volume (Disch Channel): | 85,855 | CY |
| Estimated Contaminated Soil Removed/Hauled Moist Wt: | 392,562 | Tons (based on 1.5 Tons/CY Moist Unit Wt) |
| Total Estimated Ash and Contaminated Soil Removed/Hauled Volume: | 5,402,353 | CY |
| Total Estimated Ash and Contaminated Soil Removed/Hauled Moist Wt: | 6,561,336 | Tons (based on Moist Unit Wt ) |
| Total Estimated Ash and Contaminated Soil Placed in Landfill Volume: | 4,321,882 | Tons (based on 0.8 x Volume Hauled ) |

**Estimate Notes:**

1. This estimate is represented as Rough Order of Magnitude (ROM).

**Roxboro WAB Closure Option 5 - Close in Place Hybrid (Minimum Excavation)**

**Closure Option Opinion of Probable Cost (ROM)**

**Duke Energy - Roxboro Steam Station**

**Person County, NC**

**1/8/2016**

| | Quantity | Unit | Unit Cost | Total Cost | Estimate Note |
|---|---|---|---|---|---|
| **PROPERTY ACQUISTION** | | | | | |
| Property Acquition Cost | 0 | Acres | $3,000 | $ - | Best estimate of property values in area from review of tax values and for sale listing for large tracts in Person County. NOT VERIFIED. |
| **SUBTOTAL PROPERTY ACQUISTION** | | | | $ - | |
| **GENERAL** | | | | | |
| Mobilization | 1 | LS | | $ - | Estimate at 5% of Final Closure Construction Cost (see below) |
| Surveying | 186 | Acres | $ 2,000 | $ 372,000 | |
| Abandon WAB Discharge Outlet Structures | 2 | EA | $ 150,000 | $ 300,000 | Estimate at $150k/riser |
| **SUBTOTALGENERAL** | | | | $ 672,000 | |
| **EROSION/SEDIMENT CONTROL AND STORMWATER MANAGEMENT** | | | | | |
| West Ash Basin Sediment Control and Stormwater Management | 186 | Acres | $14,000.00 | $ 2,604,000 | Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. Includes silt fence, wattles, surface water diversions, sediment basins, temporary seeding and permanent seeding. |
| Landfill Area Sediment Control and Stormwater Management | 0 | Acres | $14,000.00 | $ - | Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. Includes silt fence, wattles, surface water diversions, sediment basins, temporary seeding and permanent seeding. |
| Breaching WAP Dike No. 1 | 1 | LS | $500,000 | $ 500,000 | Place holder for cost with no technical basis. NOT VERIFIED..... |
| Permanent Drainage and Surface Stabilization Measures | 186 | Acres | $14,000 | $ 2,604,000 | Place holder for cost with no technical basis. NOT VERIFIED..... |
| | | | | $ - | |
| | | | | $ - | |
| | | | | $ - | |
| | | | | $ - | |
| **SUBTOTAL EROSION/SEDIMENT CONTROL AND STORMWATER MANAGEMENT** | | | | $ 5,708,000 | |
| **EARTHWORK** | | | | | |
| **Ash Basin Earthwork** | | | | | |
| Construction Entrance | 1000 | LF | $65 | $ 65,000 | Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. |
| Clearing and Grubbing | 5 | Acres | $5,000 | $ 25,000 | Clear and remove vegetation including trees, brush, schrubs. Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. Increased to $5000/acre from review by NWH. |
| Topsoil Stripping | 5 | Acres | $4,000 | $ 20,000 | Strip topsoil to a minimum 6-inch depth and place in stockpile. Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. Incresed to $4000/acre from review by NWH. |
| Earthwork Cut to Waste | 0 | CY | $6.25 | $ - | Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. |
| Earthwork Cut to Fill | 1,314,364 | CY | $6.25 | $ 8,214,775 | Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. |
| Soil Material (18 inches, minimum, source material on-site ) | | CY | $13 | $ - | Load, haul, place, and grade common borrow soil material. Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. |
| Topsoil Material; if required (6-inch thick un-compacted fill, source material off-site) | | CY | $13 | $ - | Load, haul, place, and grade topsoil material. Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. |
| **Landfill Earthwork** | | | | | |
| Construction Entrance | 0 | LF | $65 | $ - | Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. |
| Clearing and Grubbing | 0 | Acres | $5,000 | $ - | Clear and remove vegetation including trees, brush, schrubs. Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. Increased to $5000/acre from review by NWH. |
| Topsoil Stripping | 0 | Acres | $4,000 | $ - | Strip topsoil to a minimum 6-inch depth and place in stockpile. Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. Incresed to $4000/acre from review by NWH. |
| Earthwork cut to fill | 0 | CY | $5.40 | $ - | Grade the site following ash material removal to promote storm water management; grading will be performed to balance cut/fill related to remaining dike/berm soil materials. Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. |
| Stockpiling of Excavation Soils | 0 | CY | $0.50 | $ - | Grade the site following ash material removal to promote storm water management; grading will be performed to balance cut/fill related to remaining dike/berm soil materials. Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. |
| Perimeter Grading | 0 | CY | $0.50 | $ - | Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. |
| Soil Material (18 inches, minimum, source material on-site ) | | CY | $13 | $ - | Load, haul, place, and grade common borrow soil material. Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. |
| Topsoil Material; if required (6-inch thick un-compacted fill, source material off-site) | | CY | $13 | $ - | Load, haul, place, and grade topsoil material. Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. |
| **SUBTOTAL EARTHWORK** | | | | $ 8,324,775 | |
| **ASH BASIN DEWATERING, EXCAVATION, HAULING AND PLACEMENT** | | | | | |
| Temporary Dewatering for WAB Free Water (Estimate 162 million gallons) | 500 | Hours | $750.00 | $ 375,000 | Estimate based on Roxboro West Ash Pond H&H Issuses Improvement Plan, Dewatering/Pumping Plan. Assume drawdown limited to 1 foot/day will require pumping capacity of about 7500 GPM. Estimated time required for initial drawdown: 162,000,000 Gal/7500 GPM x 60 = 360 hours. Use 500 hours for estimating purposes to provide est contingency. Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. |
| Temporary Dewatering for WAB base inflow and stormwater during construction (assume duration of construction to be 1 years) | 1,460 | Hours | $750.00 | $ 1,095,000 | Estimate pumping required intermittently for duration of excavation to handle base flow and stormwater inflow. For estimating purposes, assume that pumping will be required for at least 4 hours/day for duration of construction. 4 hr/day x 365 days/yr x 1 year construction duration = 3942 hrs. Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates.. |
| Temporary Dewatering for WAB Discharge Channel Free Water (Estimate 7.5 million gallons) | 100 | Hours | $750.00 | $ 75,000 | Assume drawdown with pumping capacity of 2000 GPM. Estimated time required for initial drawdown: 7,500,000 Gal//2000 GPM x 60 = 62.5 hours. Use 100 hours for estimating purposes. Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. No adjustment for pumping capacity recommended for pumping unit cost. |
| Temporary Dewatering for WAB base inflow and stormwater during construction (assume duration of construction to be 6 months) | 730 | Hours | $750.00 | $ 547,500 | Estimate pumping required intermittently for duration of excavation to handle base flow and stormwater inflow. For estimating purposes, assume that pumping will be required for at least 4 housr/day for duration of construction. 4 hr/day x 365 days/yr x 0.5 year construction duration = 730 hrs. Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates.. |
| Water Treatment/Management | 1 | LS | $500,000 | $ 500,000 | Place holder for cost with no technical basis. NOT VERIFIED..... |
| Haul Road Construction | 6,000 | LF | $60 | $ 360,000 | Amec Foster Wheeler experience based on 12-inch thick ABC and supporting geotextile at 20-foot width. Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. |
| Excavation and Loading of Pond Ash for Truck Hauling | 1,314,364 | CY | $2.50 | $ 3,285,910 | Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. |
| Excavation and Loading of Subsurface Soils for Truck Hauling | 85,855 | CY | $2.50 | $ 214,638 | Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. |
| (On-Road) Hauling of Pond Ash and Impacted Soils for Off-site Landfill __ miles | | CY | $6.50 | $ - | Haul with on road dump trucks assumed with 17 cy max capacity. Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. Adjust for on road and distance using look up table. |
| (Off Road) Hauling of Pond Ash and Impacted Soils 0.7 miles | 1,400,219 | CY | $2.05 | $ 2,870,449 | Haul with off road dump trucks assumed with 17 cy max capacity. Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. Adjust for off road and distance using look up table. Use rate of $2.05/cy min. |
| Placement of Pond Ash and Impacted Soils (Use placed volume) | | CY | $1.31 | $ - | Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. |
| Truck Wash | 4 | EA | $150,000 | $ 600,000 | Truck wash necessary to clean tires and undercarriage of trucks for over-the-road hauling. Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. |
| Bridge Repair and Maintenance | 0 | LS | $500,000 | $ - | Placed holder estimate for potential bridge repair and maintenance cost. NOT VERIFIED. |
| Paved Haul Road Repair | 0 | LF | $120 | $ - | Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. |
| **SUBTOTAL ASH BASIN DEWATERING, EXCAVATION, HAULING AND PLACEMENT** | | | | $ 9,923,496 | |
| **LANDFILL & CLOSE IN PLACE COVER CONSTRUCTION** | | | | | |
| **Liner System Construction** | | | | | |
| Anchor Trench | 0 | LF | 6.00 | $ - | Unit Cost based on Amec Foster Wheeler experience and previous landfill cost estimates. |
| 8 oz/sy Non-Woven Geotextile | 0 | SY | 3.00 | $ - | Furnish and install geotextile as a cushion layer. Unit costs from Glover; costs typically include material, QC testing, and installation |
| Geosynthetic Clay Liner | 0 | SF | 0.73 | $ - | Unit Cost based on Amec Foster Wheeler experience and previous landfill cost estimates. |
| Textured 60-mil HDPE Geomembrane | 0 | SF | 0.64 | $ - | Unit Cost based on Amec Foster Wheeler experience and previous landfill cost estimates. |
| Geocomposite Drainage Layer | 0 | SF | $0.91 | $ - | Unit Cost based on Amec Foster Wheeler experience and previous landfill cost estimates. |
| Protective Cover Fill | 0 | CY | $13.00 | $ - | Unit Cost based on Amec Foster Wheeler experience and previous landfill cost estimates. |

**Roxboro WAB Closure Option 5 - Close in Place Hybrid (Minimum Excavation)**

**Closure Option Opinion of Probable Cost (ROM)**

**Duke Energy - Roxboro Steam Station**

**Person County, NC**

**1/8/2016**

| | Quantity | Unit | Unit Cost | Total Cost | Estimate Note |
|---|---|---|---|---|---|
| Drainage Aggregate for Sump | 0 | CY | $67.00 | $ - | Unit Cost based on Amec Foster Wheeler experience and previous landfill cost estimates. |
| Fine Aggregate for Sump | 0 | CY | $55.00 | $ - | Unit Cost based on Amec Foster Wheeler experience and previous landfill cost estimates. |
| LCS Riser Pipes | 0 | LF | $190.00 | $ - | Unit Cost based on Amec Foster Wheeler experience and previous landfill cost estimates. |
| **Cover System Construction** | | | | | |
| Subgrade Preparation | | Acres | $5,000.00 | $ - | Grade surface of subbase prior to installation of final cover system. Unit costs from construction contractor |
| Anchor Trench | | LF | $6.00 | $ - | Furnish and install geotextile as a cushion layer. Unit costs from Glover; costs typically include material, QC testing, and installation |
| Geosynthetic Clay Liner (GCL) - Not required | | SF | $0.73 | $ - | Furnish and install geotextile as a cushion layer. Unit costs from Glover; costs typically include material, QC testing, and installation |
| 8 oz/sy Non-Woven Geotextile | | SY | 3.00 | $ - | Furnish and install geotextile as a cushion layer. Unit costs from Glover; costs typically include material, QC testing, and installation |
| Cover System Geosynthetics (40-mil LLDPE Geomembrane and Geocomposite Drainage Layer | | SF | $1.45 | $ - | Unit Cost based on Amec Foster Wheeler experience and previous landfill cost estimates. |
| Cover System 18" Soil Cover | 0 | CY | $13.00 | $ - | Unit Cost based on Amec Foster Wheeler experience and previous landfill cost estimates. |
| Cover System Top Soil Placement | 0 | CY | $13.00 | $ - | Unit Cost based on Amec Foster Wheeler experience and previous landfill cost estimates. |
| **Close in Place Option Cover System Construction** | | | | | |
| Subgrade Preparation | 186 | Acres | $5,000.00 | $ 930,000 | Grade surface of subbase prior to installation of final cover system. Unit costs from construction contractor |
| Anchor Trench | 9,000 | LF | $6.00 | $ 54,000 | Furnish and install geotextile as a cushion layer. Unit costs from Glover; costs typically include material, QC testing, and installation |
| Geosynthetic Clay Liner (GCL) - Not required | 0 | SF | $0.73 | $ - | Furnish and install geotextile as a cushion layer. Unit costs from Glover; costs typically include material, QC testing, and installation |
| 8 oz/sy Non-Woven Geotextile | 900,240 | SY | 3.00 | $ 2,700,720 | Furnish and install geotextile as a cushion layer. Unit costs from Glover; costs typically include material, QC testing, and installation |
| Cover System Geosynthetics (40-mil LLDPE Geomembrane and Geocomposite Drainage Layer | 8,102,160 | SF | $1.45 | $ 11,748,132 | Unit Cost based on Amec Foster Wheeler experience and previous landfill cost estimates. |
| Cover System 18" Soil Cover | 450,120 | CY | $13.00 | $ 5,851,560 | Unit Cost based on Amec Foster Wheeler experience and previous landfill cost estimates. |
| Cover System Top Soil Placement | 150,040 | CY | $13.00 | $ 1,950,520 | Unit Cost based on Amec Foster Wheeler experience and previous landfill cost estimates. |
| **SUBTOTAL LANDFILL & COVER SYSTEM CONSTRUCTION** | | | | **$ 23,234,932** | |
| | | | | | |
| **SUBTOTAL FINAL CLOSURE CONSTRUCTION COST** | | | | **$ 47,863,203** | |
| **Estimate Mobilization Cost (5% of Final Closure Construction Cost)** | | | | **$ 2,393,160** | |
| **OTHER COST** | | | | | |
| **Design, Permitting and CQA** | | | | | |
| Closure Design/Engineering/Permitting (10% of Final Closure Construction Costs) | 1 | LS | $ 4,786,320 | $ 4,786,320 | Amec Foster Wheeler experience from previous projects |
| Construction Quality Assurance (CQA) (12% of Final Closure Construction Costs) | 1 | LS | $ 5,743,584 | $ 5,743,584 | Amec Foster Wheeler experience from previous projects |
| **Subtotal Design, Permitting and CQA** | | | | **$ 10,529,905** | |
| **Post Closure Operations and Maintenance (analysis based on 30 year duration)** | | | | | |
| Close in Place (Capped) Area Maintenance (186 acres) | 30 | YR | $ 316,200 | $ 9,486,000 | Estimate at $1700/acre/year of capped area. |
| Close in Place (Capped) Area Monitoring | 30 | YR | $ 58,000 | $ 1,740,000 | Amec Foster Wheeler experience from previous projects |
| Landfill Area Maintenance (0 acres) | 0 | YR | $ - | $ - | Estimate at $1700/acre/year of lined landfill area. |
| Landfill Area Monitoring | 0 | YR | $ 58,000 | $ - | Amec Foster Wheeler experience from previous projects |
| **Subtotal Post Closure Operations and Maintenance** | | | | **$ 11,226,000** | |
| **Additional Costs** | | | | | |
| Contingency (15% of Final Closure Construction Costs) | 1 | LS | $ 7,179,481 | $ 7,179,481 | Amec Foster Wheeler experience from previous projects |
| **Subtotal Additional Costs** | | | | **$ 7,179,481** | |
| | | | | | |
| **TOTAL OPINION OF PROBABLE CLOSURE COST** | | | | **$ 79,191,749** | Rough Order of Magniture Cost Estimate |
| **OPINION OF PROBABLE CLOSURE COST PER CY** | | | | **$ 60.25** | Based on Volume Placed in landfill |
| **OPINION OF PROBABLE CLOSURE COST PER TON** | | | | **$ 50.21** | Based on Moist Unit Weight of 1.2 Tons/CY |
| **OPINION OF PROBABLE CLOSURE COST PER ACRE** | | | | **$ 425,762** | Based on Estimated Closue Area |

**ESTIMATED QUANTITIES**

| Description | Est Quantity | Units |
|---|---|---|
| Estimated Landfill Property Area: | 0 | Acres |
| Estimated Landfill Development Area (including buffer and borrow area): | 0 | Acres |
| Estimated Lined Landfill Area: | 0 | Acres |
| Estimated West Ash Basin Closure Area: | 186 | Acres |
| Estimated WAB Restoration Area (after ash removal): | 0 | Acres |
| Estimated Close in Place Area | 186 | Acres |
| Estimated Ash Material Removed/Hauled Volume: | 1,314,364 | CY |
| Estimated Ash Material Removed/Hauled Moist Wt: | 1,577,237 | Tons (bsed on 1.2 Tons/CY Moist Unit Wt) |
| Estimated Contaminated Soil Removed/Hauled Volume (WAB): | 0 | CY |
| Estimated Contaminated Soil Removed/Hauled Volume (Disch Channel): | 85,855 | CY |
| Estimated Contaminated Soil Removed/Hauled Moist Wt: | 128,783 | Tons (based on 1.5 Tons/CY Moist Unit Wt) |
| Total Estimated Ash and Contaminated Soil Removed/Hauled Volume: | 1,400,219 | CY |
| Total Estimated Ash and Contaminated Soil Removed/Hauled Moist Wt: | 1,706,019 | Tons (based on Moist Unit Wt ) |
| Total Estimated Ash and Contaminated Soil Placed in Landfill Volume: | 1,120,175 | Tons (based on 0.8 x Volume Hauled ) |

**Estimate Notes:**

1. This estimate is represented as Rough Order of Magnitude (ROM).

**Roxboro WAB Closure Option 6 - Close in Place Hybrid (Combination Close in Place/Landfill)**

**Closure Option Opinion of Probable Cost (ROM)**

**Duke Energy - Roxboro Steam Station**

**Person County, NC**

**1/8/2016**

| | Quantity | Unit | Unit Cost | Total Cost | Estimate Note |
|---|---|---|---|---|---|
| **PROPERTY ACQUISTION** | | | | | |
| Property Acquition Cost | 0 | Acres | $3,000 | $ - | Best estimate of property values in area from review of tax values and for sale listing for large tracts in Person County. NOT VERIFIED. |
| **SUBTOTAL PROPERTY ACQUISTION** | | | | $ - | |
| **GENERAL** | | | | | |
| Mobilization | 1 | LS | | $ - | Estimate at 5% of Final Closure Construction Cost (see below) |
| Surveying | 186 | Acres | $ 2,000 | $ 372,000 | |
| Abandon WAB Discharge Outlet Structures | 2 | EA | $ 150,000 | $ 300,000 | Estimate at $150k/riser |
| **SUBTOTALGENERAL** | | | | $ 672,000 | |
| **EROSION/SEDIMENT CONTROL AND STORMWATER MANAGEMENT** | | | | | |
| West Ash Basin Sediment Control and Stormwater Management | 186 | Acres | $14,000.00 | $ 2,604,000 | Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. Includes silt fence, wattles, surface water diversions, sediment basins, temporary seeding and permanent seeding. |
| Landfill Area Sediment Control and Stormwater Management | 102 | Acres | $14,000.00 | $ 1,428,000 | Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. Includes silt fence, wattles, surface water diversions, sediment basins, temporary seeding and permanent seeding. |
| Breaching WAB Main Dam | 1 | LS | $1,000,000 | $ 1,000,000 | Place holder for cost with no technical basis. NOT VERIFIED..... |
| Permanent Drainage and Surface Stabilization Measures | 186 | Acres | $14,000 | $ 2,604,000 | Place holder for cost with no technical basis. NOT VERIFIED..... |
| | | | | $ - | |
| | | | | $ - | |
| | | | | $ - | |
| | | | | $ - | |
| **SUBTOTAL EROSION/SEDIMENT CONTROL AND STORMWATER MANAGEMENT** | | | | $ 7,636,000 | |
| **EARTHWORK** | | | | | |
| **Ash Basin Earthwork** | | | | | |
| Construction Entrance | 1000 | LF | $65 | $ 65,000 | Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. |
| Clearing and Grubbing | 5 | Acres | $5,000 | $ 25,000 | Clear and remove vegetation including trees, brush, schrubs. Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. Increased to $5000/acre from review by NWH. |
| Topsoil Stripping | 5 | Acres | $4,000 | $ 20,000 | Strip topsoil to a minimum 6-inch depth and place in stockpile. Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. Incresed to $4000/acre from review by NWH. |
| Earthwork Cut to Waste | 0 | CY | $6.25 | $ - | Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. |
| Earthwork Cut to Fill (grading for site drainage) | 534,519 | CY | $6.25 | $ 3,340,744 | Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. |
| Soil Material (for site drainage) | 534,519 | CY | $13 | $ 6,948,747 | Load, haul, place, and grade common borrow soil material. Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. |
| Topsoil Material; if required (6-inch thick un-compacted fill, source material off-site) | | CY | $13 | $ - | Load, haul, place, and grade topsoil material. Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. |
| **Landfill Earthwork** | | | | | |
| Construction Entrance | 1000 | LF | $65 | $ 65,000 | Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. Adjst based on factor = |
| Clearing and Grubbing | 200 | Acres | $5,000 | $ 1,000,000 | Clear and remove vegetation including trees, brush, schrubs. Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. Increased to $5000/acre from review by NWH. |
| Topsoil Stripping | 200 | Acres | $4,000 | $ 800,000 | Strip topsoil to a minimum 6-inch depth and place in stockpile. Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. Incresed to $4000/acre from review by NWH. |
| Earthwork cut to fill | 1,700,000 | CY | $5.40 | $ 9,180,000 | Grade the site following ash material removal to promote storm water management; grading will be performed to balance cut/fill related to remaining dike/berm soil materials. Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. |
| Stockpiling of Excavation Soils | 2,000,000 | CY | $0.50 | $ 1,000,000 | Grade the site following ash material removal to promote storm water management; grading will be performed to balance cut/fill related to remaining dike/berm soil materials. Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. |
| Perimeter Grading | 50000 | CY | $5.40 | $ 270,000 | Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. |
| Soil Material (18 inches, minimum, source material on-site ) | | CY | $13 | $ - | Load, haul, place, and grade common borrow soil material. Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. |
| Topsoil Material; if required (6-inch thick un-compacted fill, source material off-site) | | CY | $13 | $ - | Load, haul, place, and grade topsoil material. Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. |
| **SUBTOTAL EARTHWORK** | | | | $ 22,714,491 | |
| **ASH BASIN DEWATERING, EXCAVATION, HAULING AND PLACEMENT** | | | | | |
| Temporary Dewatering for WAB Free Water (Estimate 162 million gallons) | 500 | Hours | $750.00 | $ 375,000 | Estimate based on Roxboro West Ash Pond H&H Issuses Improvement Plan, Dewatering/Pumping Plan. Assume drawdown limited to 1 foot/day will require pumping capacity of about 7500 GPM. Estimated time required for initial drawdown: 162,000,000 Gal/7500 GPM x 60 = 360 hours. Use 500 hours for estimating purposes to provide est contingency. Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. |
| Temporary Dewatering for WAB base inflow and stormwater during construction (assume duration of construction to be 2.7 years) | 3,942 | Hours | $750.00 | $ 2,956,500 | Estimate pumping required intermittently for duration of excavation to handle base flow and stormwater inflow. For estimating purposes, assume that pumping will be required for at least 4 hours/day for duration of construction. 4 hr/day x 365 days/yr x 2.7 year construction duration = 3942 hrs. Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates.. |
| Temporary Dewatering for WAB Discharge Channel Free Water (Estimate 7.5 million gallons) | 100 | Hours | $750.00 | $ 75,000 | Assume drawdown with pumping capacity of 2000 GPM. Estimated time required for initial drawdown: 7,500,000 Gal//2000 GPM x 60 = 62.5 hours. Use 100 hours for estimating purposes. Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. No adjustment for pumping capacity recommended for pumping unit cost. |
| Temporary Dewatering for WAB base inflow and stormwater during construction (assume duration of construction to be 6 months) | 730 | Hours | $750.00 | $ 547,500 | Estimate pumping required intermittently for duration of excavation to handle base flow and stormwater inflow. For estimating purposes, assume that pumping will be required for at least 4 housr/day for duration of construction. 4 hr/day x 365 days/yr x 0.5 year construction duration = 730 hrs. Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates.. |
| Water Treatment/Management | 1 | LS | $500,000 | $ 500,000 | Place holder for cost with no technical basis. NOT VERIFIED..... |
| Haul Road Construction (1 mile) | 6,000 | LF | $60 | $ 360,000 | Amec Foster Wheeler experience based on 12-inch thick ABC and supporting geotextile at 20-foot width. Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. |
| Excavation and Loading of Pond Ash for Truck Hauling | 5,140,645 | CY | $2.50 | $ 12,851,613 | Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. |
| Excavation and Loading of Subsurface Soils for Truck Hauling | 175,853 | CY | $2.50 | $ 439,633 | Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. |
| (On-Road) Hauling of Pond Ash and Impacted Soils for Off-site Landfill __ miles | | CY | $6.50 | $ - | Haul with on road dump trucks assumed with 17 cy max capacity. Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. Adjust for on road and distance using look up table. |
| (Off Road) Hauling of Pond Ash and Impacted Soils for On-site Landfill 1.2 miles | 5,402,353 | CY | $2.46 | $ 13,289,788 | Haul with off road dump trucks assumed with 17 cy max capacity. Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. Adjust for off road and distance using look up table. |
| Placement of Pond Ash and Impacted Soils In Landfill (Use placed volume) | 4,321,882 | CY | $1.31 | $ 5,661,666 | Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. |
| Truck Wash | 4 | EA | $150,000 | $ 600,000 | Truck wash necessary to clean tires and undercarriage of trucks for over-the-road hauling. Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. |
| Bridge Repair and Maintenance | 0 | LS | $500,000 | $ - | Placed holder estimate for potential bridge repair and maintenance cost. NOT VERIFIED. |
| Paved Haul Road Repair | 1,000 | LF | $120 | $ 120,000 | Unit Cost based on Amec Foster Wheeler experience and previous closure option cost estimates. |
| **SUBTOTAL ASH BASIN DEWATERING, EXCAVATION, HAULING AND PLACEMENT** | | | | $ 37,776,699 | |
| **LANDFILL & CLOSE IN PLACE COVER CONSTRUCTION** | | | | | |
| **Liner System Construction (Apply Adjustment Factor = 41 acres/86 acres = 0.48 to WAB Option 3 Quantities for Liner Estimate)** | | | | | |
| Anchor Trench | 9,000 | LF | 6.00 | $ 54,000 | Unit Cost based on Amec Foster Wheeler experience and previous landfill cost estimates. |
| 8 oz/sy Non-Woven Geotextile | 198,440 | SY | 3.00 | $ 595,320 | Furnish and install geotextile as a cushion layer. Unit costs from Glover; costs typically include material, QC testing, and installation |
| Geosynthetic Clay Liner | 1,785,960 | SF | 0.73 | $ 1,303,751 | Unit Cost based on Amec Foster Wheeler experience and previous landfill cost estimates. |
| Textured 60-mil HDPE Geomembrane | 2,160,000 | SF | 0.64 | $ 1,382,400 | Unit Cost based on Amec Foster Wheeler experience and previous landfill cost estimates. |
| Geocomposite Drainage Layer | 2,160,000 | SF | $0.91 | $ 1,965,600 | Unit Cost based on Amec Foster Wheeler experience and previous landfill cost estimates. |
| Protective Cover Fill | 120,000 | CY | $13.00 | $ 1,560,000 | Unit Cost based on Amec Foster Wheeler experience and previous landfill cost estimates. |

**Roxboro WAB Closure Option 6 - Close in Place Hybrid (Combination Close in Place/Landfill)**

**Closure Option Opinion of Probable Cost (ROM)**

**Duke Energy - Roxboro Steam Station**

**Person County, NC**

**1/8/2016**

| | Quantity | Unit | Unit Cost | Total Cost | Estimate Note |
|---|---|---|---|---|---|
| Drainage Aggregate for Sump | 375 | CY | $67.00 | $ 25,125 | Unit Cost based on Amec Foster Wheeler experience and previous landfill cost estimates. |
| Fine Aggregate for Sump | 65 | CY | $55.00 | $ 3,575 | Unit Cost based on Amec Foster Wheeler experience and previous landfill cost estimates. |
| LCS Riser Pipes | 285 | LF | $190.00 | $ 54,150 | Unit Cost based on Amec Foster Wheeler experience and previous landfill cost estimates. |
| **Cover System Construction** | | | | | |
| Subgrade Preparation | 41 | Acres | $5,000.00 | $ 205,000 | Grade surface of subbase prior to installation of final cover system. Unit costs from construction contractor |
| Anchor Trench | 9,000 | LF | $6.00 | $ 54,000 | Furnish and install geotextile as a cushion layer. Unit costs from Glover; costs typically include material, QC testing, and installation |
| Geosynthetic Clay Liner (GCL) - Not required | 0 | SF | $0.73 | $ - | Furnish and install geotextile as a cushion layer. Unit costs from Glover; costs typically include material, QC testing, and installation |
| 8 oz/sy Non-Woven Geotextile | 1,785,960 | SY | 3.00 | $ 5,357,880 | Furnish and install geotextile as a cushion layer. Unit costs from Glover; costs typically include material, QC testing, and installation |
| Cover System Geosynthetics (40-mil LLDPE Geomembrane and Geocomposite Drainage Layer | 1,785,960 | SF | $1.45 | $ 2,589,642 | Unit Cost based on Amec Foster Wheeler experience and previous landfill cost estimates. |
| Cover System 18" Soil Cover | 99,220 | CY | $13.00 | $ 1,289,860 | Unit Cost based on Amec Foster Wheeler experience and previous landfill cost estimates. |
| Cover System Top Soil Placement | 33,073 | CY | $13.00 | $ 429,953 | Unit Cost based on Amec Foster Wheeler experience and previous landfill cost estimates. |
| **Close in Place Option Cover System Construction** | | | | | |
| Subgrade Preparation | 77 | Acres | $5,000.00 | $ 385,000 | Grade surface of subbase prior to installation of final cover system. Unit costs from construction contractor |
| Anchor Trench | 9,000 | LF | $6.00 | $ 54,000 | Furnish and install geotextile as a cushion layer. Unit costs from Glover; costs typically include material, QC testing, and installation |
| Geosynthetic Clay Liner (GCL) - Not required | 0 | SF | $0.73 | $ - | Furnish and install geotextile as a cushion layer. Unit costs from Glover; costs typically include material, QC testing, and installation |
| 8 oz/sy Non-Woven Geotextile | 3,354,120 | SY | 3.00 | $ 10,062,360 | Furnish and install geotextile as a cushion layer. Unit costs from Glover; costs typically include material, QC testing, and installation |
| Cover System Geosynthetics (40-mil LLDPE Geomembrane and Geocomposite Drainage Layer | 3,354,120 | SF | $1.45 | $ 4,863,474 | Unit Cost based on Amec Foster Wheeler experience and previous landfill cost estimates. |
| Cover System 18" Soil Cover | 186,340 | CY | $13.00 | $ 2,422,420 | Unit Cost based on Amec Foster Wheeler experience and previous landfill cost estimates. |
| Cover System Top Soil Placement | 62,113 | CY | $13.00 | $ 807,473 | Unit Cost based on Amec Foster Wheeler experience and previous landfill cost estimates. |
| **SUBTOTAL LANDFILL CONSTRUCTION** | | | | **$ 35,464,983** | |
| | | | | | |
| **SUBTOTAL FINAL CLOSURE CONSTRUCTION COST** | | | | **$ 104,264,174** | |
| **Estimate Mobilization Cost (5% of Final Closure Construction Cost)** | | | | **$ 5,213,209** | |
| **OTHER COST** | | | | | |
| **Design, Permitting and CQA** | | | | | |
| Closure Design/Engineering/Permitting (10% of Final Closure Construction Costs) | 1 | LS | $ 10,426,417 | $ 10,426,417 | Amec Foster Wheeler experience from previous projects |
| Construction Quality Assurance (CQA) (12% of Final Closure Construction Costs) | 1 | LS | $ 12,511,701 | $ 12,511,701 | Amec Foster Wheeler experience from previous projects |
| **Subtotal Design, Permitting and CQA** | | | | **$ 22,938,118** | |
| **Post Closure Operations and Maintenance (analysis based on 30 year duration)** | | | | | |
| Close in Place (Capped) Area Maintenance (77 acres) | 30 | YR | $ 130,900 | $ 3,927,000 | Estimate at $1700/acre/year of capped area. |
| Close in Place (Capped) Area Monitoring | 30 | YR | $ 58,000 | $ 1,740,000 | Amec Foster Wheeler experience from previous projects |
| Landfill Area Maintenance (41 acres) | 30 | YR | $ 69,700 | $ 2,091,000 | Estimate at $1700/acre/year of lined landfill area. |
| Landfill Area Monitoring | 30 | YR | $ 58,000 | $ 1,740,000 | Amec Foster Wheeler experience from previous projects |
| **Subtotal Post Closure Operations and Maintenance** | | | | **$ 9,498,000** | |
| **Additional Costs** | | | | | |
| Contingency (15% of Final Closure Construction Costs) | 1 | LS | $ 15,639,626 | $ 15,639,626 | Amec Foster Wheeler experience from previous projects |
| **Subtotal Additional Costs** | | | | **$ 15,639,626** | |
| | | | | | |
| **TOTAL OPINION OF PROBABLE CLOSURE COST** | | | | **$ 157,553,126** | Rough Order of Magniture Cost Estimate |
| **OPINION OF PROBABLE CLOSURE COST PER CY** | | | | **$ 30.65** | Based on Volume Placed in landfill |
| **OPINION OF PROBABLE CLOSURE COST PER TON** | | | | **$ 25.54** | Based on Moist Unit Weight of 1.2 Tons/CY |
| **OPINION OF PROBABLE CLOSURE COST PER ACRE** | | | | **$ 847,060** | Based on Estimated Closue Area |

**ESTIMATED QUANTITIES**

| Description | Est Quantity | Units |
|---|---|---|
| Estimated Landfill Property Area: | 0 | Acres |
| Estimated Landfill Development Area (including buffer and borrow area): | 102 | Acres |
| Estimated Lined Landfill Area: | 41 | Acres |
| Estimated West Ash Basin Closure Area: | 186 | Acres |
| Estimated WAB Restoration Area (after ash removal): | 109 | Acres |
| Estimated Close in Place Area: | 77 | Acres |
| Estimated Ash Material Removed/Hauled Volume: | 5,140,645 | CY |
| Estimated Ash Material Removed/Hauled Moist Wt: | 6,168,774 | Tons (bsed on 1.2 Tons/CY Moist Unit Wt) |
| Estimated Contaminated Soil Removed/Hauled Volume (WAB): | 175,853 | CY |
| Estimated Contaminated Soil Removed/Hauled Volume (Disch Channel): | 85,855 | CY |
| Estimated Contaminated Soil Removed/Hauled Moist Wt: | 392,562 | Tons (based on 1.5 Tons/CY Moist Unit Wt) |
| Total Estimated Ash and Contaminated Soil Removed/Hauled Volume: | 5,402,353 | CY |
| Total Estimated Ash and Contaminated Soil Removed/Hauled Moist Wt: | 6,561,336 | Tons (based on Moist Unit Wt ) |
| Total Estimated Ash and Contaminated Soil Placed in Landfill Volume: | 4,321,882 | Tons (based on 0.8 x Volume Hauled ) |

**Estimate Notes:**

1. This estimate is represented as Rough Order of Magnitude (ROM).

Roxboro Closure Options Evaluation
Duke Energy
Amec Foster Wheeler Project No. 7810150347
ATTACHMENTS

- WAB Schedule Analysis

**Roxboro Ash Basin Closure Project**
**Schedule Duration Estimate Worksheet**
**Roxboro West Ash Basin**
**Prepared By: Scott Auger**
**Draft Rev. 0 (1-8-16)**

**WAB Closure Options - Project Schedule Summary**

| Option | Description | Estimated Duration (Months) | Estimated Duration (Years) | Est Time to Start Ash Removal (Months) |
|---|---|---|---|---|
| WAB Option 1 | Closure by Removal (with On-site Landfill) | 142 | 11.8 | 52 |
| WAB Option 2 | Closure by Removal (with Off-site Landfill) | 228 | 19.0 | 75 |
| WAB Option 3 | Closure by Removal (with EAB Phases 7-9 Landfill) | 142 | 11.8 | 52 |
| WAB Option 4 | Close in Place Hybrid Option (CAP Concept) | 92 | 7.7 | 21 |
| WAB Option 5 | Close in Place Hybrid Option (Minimum Excavation) | 98 | 8.1 | 21 |
| WAB Option 6 | Close in Place Hybrid Option (Combination of Close in Place and Landfill) | 105 | 8.7 | 40 |

**WAB Closure Option 1 - Closure by Removal (with On-Site Landfill)**

| Activity | Activity Description | Est Activity Duration (Months) | Cum Duration (Months) | Cum Duration (Years) | |
|---|---|---|---|---|---|
| 1.0 | Landfill | | | | |
| 1.1 | Preliminary Engineering | 8 | 8 | 0.7 | |
| 1.2 | Property Acquisition | 0 | 8 | 0.7 | |
| 1.3 | Field Investigation - Finish concurrent with Activity 1.1 | 3 | 8 | 0.7 | |
| 1.4 | Permitting | 12 | 20 | 1.7 | |
| 1.5 | Construction Documents - Finish concurrent with Activity 1.4 | 6 | 20 | 1.7 | |
| 1.6 | Bidding - Start after Activity 1.5 | 3 | 23 | 1.9 | |
| 1.7 | Landfill Construction (86 acres) - Start after Activity 1.4 | 29 | 49 | 4.1 | Estimate 3 acres/month |
| 1.8 | Landfill PTO | 3 | 52 | 4.3 | |
| 2.0 | Closure Implementation (assumed critical path) | | | | |
| 2.1 | Ash and Contaminated Soil Excavation/Hauling | 66 | 118 | 9.8 | |
| 2.2 | Site Restoration | 24 | 142 | 11.8 | |
| | **Estimated Project Duration** | | **142** | **11.8** | |

**WAB Closure Option 2 - Closure by Removal (with Off-Site Landfill)**

| Activity | Activity Description | Est Activity Duration (Months) | Cum Duration (Months) | Cum Duration (Years) | |
|---|---|---|---|---|---|
| 1.0 | Landfill | | | | |
| 1.1 | Preliminary Engineering | 8 | 8 | 0.7 | |
| 1.2 | Property Acquisition | 12 | 20 | 1.7 | |
| 1.3 | Field Investigation | 3 | 23 | 1.9 | |
| 1.4 | Permitting | 12 | 35 | 2.9 | |
| 1.5 | Construction Documents - Finish concurrent with Activity 1.4 | 6 | 35 | 2.9 | |
| 1.6 | Bidding | 3 | 38 | 3.2 | |
| 1.7 | Landfill Construction (103 acres) | 34 | 72 | 6.0 | Estimate 3 acres/month |
| 1.8 | Landfill PTO | 3 | 75 | 6.3 | |
| 2.0 | Closure Implementation (assumed critical path) | | | | |
| 2.1 | Ash and Contaminated Soil Excavation/Hauling (assuming maximum haul rate of around 1 million cy/year per Duke direction) | 128 | 204 | 17.0 | |
| 2.2 | Site Restoration | 24 | 228 | 19.0 | |
| | **Estimated Project Duration** | | **228** | **19.0** | |

**WAB Closure Option 3 - Closure by Removal (with EAB Landfill Phases 7-9)**

| Activity | Activity Description | Est Activity Duration (Months) | Cum Duration (Months) | Cum Duration (Years) | |
|---|---|---|---|---|---|
| 1.0 | Landfill | | | | |
| 1.1 | Preliminary Engineering | 8 | 8 | 0.7 | |
| 1.2 | Property Acquisition | 0 | 8 | 0.7 | |
| 1.3 | Field Investigation - Finish concurrent with Activity 1.1 | 3 | 8 | 0.7 | |
| 1.4 | Permitting | 12 | 20 | 1.7 | |
| 1.5 | Construction Documents - Finish concurrent with Activity 1.4 | 6 | 20 | 1.7 | |
| 1.6 | Bidding - Start after Activity 1.5 | 3 | 23 | 1.9 | |
| 1.7 | Landfill Construction (86 acres) - Start after Activity 1.4 | 29 | 49 | 4.1 | Estimate 3 acres/month |
| 1.8 | Landfill PTO | 3 | 52 | 4.3 | |
| 2.0 | Closure Implementation (assumed critical path) | | | | |
| 2.1 | Ash and Contaminated Soil Excavation/Hauling | 66 | 118 | 9.8 | |
| 2.2 | Site Restoration | 24 | 142 | 11.8 | |
| | **Estimated Project Duration** | | **142** | **11.8** | |

**WAB Closure Option 4 - Close in Place Hybrid (CAP Concept)**

| Activity | Activity Description | Est Activity Duration (Months) | Cum Duration (Months) | Cum Duration (Years) |
|---|---|---|---|---|
| 1.0 | Landfill | | | |
| 1.1 | Planning/Preliminary Engineering | 0 | 0 | 0.0 |
| 1.2 | Property Acquisition | 0 | 0 | 0.0 |
| 1.3 | Field Investigation | 0 | 0 | 0.0 |
| 1.4 | Permitting | 0 | 0 | 0.0 |
| 1.5 | Construction Documents | 0 | 0 | 0.0 |
| 1.6 | Bidding | 0 | 0 | 0.0 |
| 1.7 | Landfill Construction | 0 | 0 | 0.0 |
| 1.8 | Landfill PTO | 0 | 0 | 0.0 |

| | | | | | |
|---|---|---|---|---|---|
| 2.0 | Closure Implementation (assumed critical path) | | | | |
| 2.1 | Permitting | 12 | 12 | 1.0 | |
| 2.2 | Construction Documents - Finish concurrent with Activity 2.1 | 6 | 12 | 1.0 | |
| 2.3 | Bidding - Start after Activity 2.2 | 3 | 15 | 1.3 | |
| 2.4 | Construction Dewatering and Site Preparation | 6 | 21 | 1.8 | |
| 2.5 | Ash and Contaminated Soil Excavation/Hauling | 33 | 48 | 4.0 | |
| 2.6 | Engineered Cover Construction (77 acres) | 26 | 74 | 6.2 | Estimate 3 acres/month |
| 2.7 | Site Restoration | 18 | 92 | 7.7 | |
| | **Estimated Project Duration** | | **92** | **7.7** | |

**WAB Closure Option 5 - Close in Place Hybrid (Minimum Excavation)**

| Activity | Activity Description | Est Activity Duration (Months) | Cum Duration (Months) | Cum Duration (Years) | |
|---|---|---|---|---|---|
| 1.0 | Landfill | | | | |
| 1.1 | Preliminary Engineering | 0 | 0 | 0.0 | |
| 1.2 | Property Acquisition | 0 | 0 | 0.0 | |
| 1.3 | Field Investigation | 0 | 0 | 0.0 | |
| 1.4 | Permitting | 0 | 0 | 0.0 | |
| 1.5 | Construction Documents | 0 | 0 | 0.0 | |
| 1.6 | Bidding | 0 | 0 | 0.0 | |
| 1.7 | Landfill Construction | 0 | 0 | 0.0 | |
| 1.8 | Landfill PTO | 0 | 0 | 0.0 | |
| 2.0 | Closure Implementation (assumed critical path) | | | | |
| 2.1 | Permitting | 12 | 12 | 1.0 | |
| 2.2 | Construction Documents - Finish concurrent with Activity 2.1 | 6 | 12 | 1.0 | |
| 2.3 | Bidding - Start after Activity 2.2 | 3 | 15 | 1.3 | |
| 2.4 | Construction Dewatering and Site Preparation | 6 | 21 | 1.8 | |
| 2.4 | Ash and Contaminated Soil Excavation/Hauling/Site Grading | 9 | 24 | 2.0 | |
| 2.5 | Engineered Cover Construction (186 acres) | 62 | 86 | 7.1 | Estimate 3 acres/month |
| 2.6 | Site Restoration | 12 | 98 | 8.1 | |
| | **Estimated Project Duration** | | **98** | **8.1** | |

**WAB Closure Option 6 - Close in Place Hybrid (Combination Close in Place/Landfill)**

| Activity | Activity Description | Est Activity Duration (Months) | Cum Duration (Months) | Cum Duration (Years) | |
|---|---|---|---|---|---|
| 1.0 | Landfill | | | | |
| 1.1 | Preliminary Engineering | 8 | 8 | 0.7 | |
| 1.2 | Property Acquisition | 0 | 8 | 0.7 | |
| 1.3 | Field Investigation - Finish concurrent with Activity 1.1 | 8 | 8 | 0.7 | |
| 1.4 | Permitting | 12 | 20 | 1.7 | |
| 1.5 | Construction Documents - Finish concurrent with Activity 1.4 | 6 | 20 | 1.7 | |
| 1.6 | Bidding | 3 | 23 | 1.9 | |
| 1.7 | Landfill Construction (41 acres) | 14 | 37 | 3.1 | Estimate 3 acres/month |
| 1.8 | Landfill PTO | 3 | 40 | 3.3 | |
| 2.0 | Closure Implementation (assumed critical path) | | | | |
| 2.1 | Ash and Contaminated Soil Excavation/Hauling | 33 | 73 | 6.1 | |
| 2.2 | Engineered Cover Construction (77 acres) | 26 | 99 | 8.2 | Estimate 3 acres/month |
| 2.3 | Site Restoration | 6 | 105 | 8.7 | |
| | **Estimated Project Duration** | | **105** | **8.7** | |

**Roxboro Ash Basin Closure Project**
**Excavation and Hauling Estimate Work Sheet**
**Roxboro West Ash Basin**
**Prepared By: Scott Auger**

**1/8/2016**

**WAB Closure Option 1 - Closure by Removal (with On-Site Landfill)**

**Key Assumptions Used for Analysis**

| Description | Est Quantity | Units | Notes/Comments |
|---|---|---|---|
| Hauling capacity for on-site disposal: | 17 | cy/truck load (assumed average capacity) | |
| Hauling capacity for off-site disposal: | 17 | cy/truck load (assumed average capacity) | |
| Average time for truck loading/unloading operations: | 20 | minutes | |
| Average speed for on site travel: | 10 | mph | |
| Average speed for off site travel: | 45 | mph | |
| Work shifts: | 1 | shifts | |
| Shift Length | 12 | hours | |
| Average Monthly Work Days | 25 | days/month | |

**Summary of Estimated Quantities**

| Description | Est Quantity | Units | Notes/Comments |
|---|---|---|---|
| Estimated On-Site Travel Distance (1 way): | 1.0 | Miles | |
| Estimated Off-Site Travel Distance (1 way): | 0.0 | Miles | |
| Total Estimated Travel Distance (1 way): | 1.0 | Miles | |
| Total Estimated Travel Distance (RT): | 2.0 | Miles | |
| Estimated Landfill Property Area: | 0 | Acres | |
| Estimated Landfill Development Area (including buffer and borrow area): | 213 | Acres | |
| Estimated Lined Landfill Area: | 86 | Acres | |
| Estimated West Ash Basin Closure Area: | 186 | Acres | |
| Estimated WAB Restoration Area (after ash removal): | 186 | Acres | |
| Estimated Ash Material Removed/Hauled Volume: | 10,382,000 | CY | |
| Estimated Ash Material Removed/Hauled Moist Wt: | 12,458,400 | Tons (bsed on 1.2 Tons/CY Moist Unit Wt) | |
| Estimated Contaminated Soil Removed/Hauled Volume (WAB): | 300,080 | CY | |
| Estimated Contaminated Soil Removed/Hauled Volume (Disch Channel): | 85,855 | CY | |
| Estimated Contaminated Soil Removed/Hauled Moist Wt: | 578,903 | Tons (based on 1.5 Tons/CY Moist Unit Wt) | |
| Total Estimated Ash and Contaminated Soil Removed/Hauled Volume: | 10,767,935 | CY | |
| Total Estimated Ash and Contaminated Soil Removed/Hauled Moist Wt: | 13,037,303 | Tons (based on Moist Unit Wt ) | |
| Total Estimated Ash and Contaminated Soil Placed in Landfill Volume: | 8,614,348 | Tons (based on 0.8 x Volume Hauled ) | |

**Calculation Summary**

| Description | Quantity | Units | Notes/Comments |
|---|---|---|---|
| Est On Site Haul Travel Distance (1 way) | 1 | Miles | See estimated quantities |
| On Site Haul RT Distance | 2 | Miles | Travel Distance x 2 |
| Assumed Avg Speed (on site) | 10 | mph | See assumptions |
| Assumed On Site Travel Time | 0.20 | hr | RT Distance/Avg Speed |
| Est Off Site Haul Distance | 0 | Miles | See estimated quantities |
| Off Site Haul RT Distance | 0 | Miles | Travel Distance x 2 |
| Assumed Avg Speed (off site) | 45 | mph | See assumptions |
| Assumed Off Site Travel Time | 0.00 | hr | RT Distance/Avg Speed |
| Assumed loading/unloading time | 0.33 | hr | See assumptions |
| Total Est Time Each Loading/Hauling/Unloading Operation | 0.53 | hr | Loading Time + Travel time |
| ***Est Haul Truck Fleet Size:*** | ***17*** | ***trucks*** | ***Adjust # vehicles here as needed for travel separation time.*** |
| Est separation time between vehicles: | 2.0 | minutes | Total Travel Time x 60/(# Trucks - 1) - 2 minutes min suggested by Tom Maier for traffic safety |
| Assumed daily hours hauled | 12 | hr | See assumptions |
| Assumed monthly days worked | 25 | days/mo | See assumptions |
| Est monthly hours hauling | 300 | hrs/truck-month | Hours Hauled/day x Days Worked/month |
| Est monthly trips per truck | 563 | trips/truck-month | Hrs/Truck-month/ Total Haul Time |
| Assumed volume per truck | 17 | cy | See assumptions |
| Est volume hauled per truck month | 9,563 | cy/truck month | Load Capacity x Trips/Truck-month |
| Est volume hauled per month (fleet) | 162,563 | cy/month | cy/Truck-month x # Trucks |
| Est volume hauled per year (fleet) | 1,950,750 | cy/year | cy/month x 12 months |
| Est volume hauled | 10,767,935 | cy | See assumptions |
| **Est time required for ash removal (months)** | **66** | **months** | **Volume Hauled/ (cy/month)** |
| **Est time required for ash removal (years)** | **5.5** | **years** | **Months/12** |
| **Est Total Trips** | **633,408** | **trips** | **Months x (trips/truck-month) x #Trucks** |
| **Total Est Miles Driven** | **1,266,816** | **Miles** | **Est Trips x Total RT Travel Distance** |
| **Est Miles Driven On Site** | **1,266,816** | **Miles** | **Total Miles x (On-site Distance/Total Distance)** |
| **Est Miles Driven Off Site** | **0** | **Miles** | **Total Miles x (Off-site Distance/Total Distance)** |
| **Estimate Fuel Consumed (assumed at 5 mpg)** | **253,363** | **gallons** | **Total Miles/assumed fuel consumption MPG** |

**Roxboro Ash Basin Closure Project**
**Excavation and Hauling Estimate Work Sheet**
**Roxboro West Ash Basin**
**Prepared By: Scott Auger**

**1/8/2016**

**WAB Closure Option 2 - Closure by Removal (with Off-Site Landfill)**

**Key Assumptions Used for Analysis**

| Description | Est Quantity | Units | Notes/Comments |
|---|---|---|---|
| Hauling capacity for on-site disposal: | 17 | cy/truck load (assumed average capacity) | |
| Hauling capacity for off-site disposal: | 17 | cy/truck load (assumed average capacity) | |
| Average time for truck loading/unloading operations: | 20 | minutes | |
| Average speed for on site travel: | 10 | mph | |
| Average speed for off site travel: | 45 | mph | |
| Work shifts: | 1 | shifts | |
| Shift Length | 12 | hours | |
| Average Monthly Work Days | 25 | days/month | |

**Summary of Estimated Quantities**

| Description | Est Quantity | Units | Notes/Comments |
|---|---|---|---|
| Estimated On-Site Travel Distance (1 way): | 1.0 | Miles | |
| Estimated Off-Site Travel Distance (1 way): | 14.0 | Miles | |
| Total Estimated Travel Distance (1 way): | 15.0 | Miles | |
| Total Estimated Travel Distance (RT): | 30.0 | Miles | |
| Estimated Landfill Property Area: | 400 | Acres | |
| Estimated Landfill Development Area (including buffer and borrow area): | 250 | Acres | |
| Estimated Lined Landfill Area: | 103 | Acres | |
| Estimated West Ash Basin Closure Area: | 186 | Acres | |
| Estimated WAB Restoration Area (after ash removal): | 186 | Acres | |
| Estimated Ash Material Removed/Hauled Volume: | 10,382,000 | CY | |
| Estimated Ash Material Removed/Hauled Moist Wt: | 12,458,400 | Tons (bsed on 1.2 Tons/CY Moist Unit Wt) | |
| Estimated Contaminated Soil Removed/Hauled Volume (WAB): | 300,080 | CY | |
| Estimated Contaminated Soil Removed/Hauled Volume (Disch Channel): | 85,855 | CY | |
| Estimated Contaminated Soil Removed/Hauled Moist Wt: | 578,903 | Tons (based on 1.5 Tons/CY Moist Unit Wt) | |
| Total Estimated Ash and Contaminated Soil Removed/Hauled Volume: | 10,767,935 | CY | |
| Total Estimated Ash and Contaminated Soil Removed/Hauled Moist Wt: | 13,037,303 | Tons (based on Moist Unit Wt ) | |
| Total Estimated Ash and Contaminated Soil Placed in Landfill Volume: | 8,614,348 | Tons (based on 0.8 x Volume Hauled ) | |

**Calculation Summary**

| Description | Quantity | Units | Notes/Comments |
|---|---|---|---|
| Est On Site Haul Travel Distance (1 way) | 1 | Miles | See estimated quantities |
| On Site Haul RT Distance | 2 | Miles | Travel Distance x 2 |
| Assumed Avg Speed (on site) | 10 | mph | See assumptions |
| Assumed On Site Travel Time | 0.20 | hr | RT Distance/Avg Speed |
| Est Off Site Haul Distance | 14 | Miles | See estimated quantities |
| Off Site Haul RT Distance | 28 | Miles | Travel Distance x 2 |
| Assumed Avg Speed (off site) | 45 | mph | See assumptions |
| Assumed Off Site Travel Time | 0.62 | hr | RT Distance/Avg Speed |
| Assumed loading/unloading time | 0.33 | hr | See assumptions |
| Total Est Time Each Loading/Hauling/Unloading Operation | 1.16 | hr | Loading Time + Travel time |
| ***Est Haul Truck Fleet Size:*** | ***19*** | ***trucks*** | ***Adjust # vehicles here as needed for travel separation time. Also, Duke requested that off site hauling be limited to about 1 million cy/year.*** |
| Est separation time between vehicles: | 3.9 | minutes | Total Travel Time x 60/(# Trucks - 1) - 2 minutes min suggested by Tom Maier for traffic safety |
| Assumed daily hours hauled | 12 | hr | See assumptions |
| Assumed monthly days worked | 25 | days/mo | See assumptions |
| Est monthly hours hauling | 300 | hrs/truck-month | Hours Hauled/day x Days Worked/month |
| Est monthly trips per truck | 260 | trips/truck-month | Hrs/Truck-month/ Total Haul Time |
| Assumed volume per truck | 17 | cy | See assumptions |
| Est volume hauled per truck month | 4,413 | cy/truck month | Load Capacity x Trips/Truck-month |
| Est volume hauled per month (fleet) | 83,856 | cy/month | cy/Truck-month x # Trucks |
| Est volume hauled per year (fleet) | 1,006,269 | cy/year | cy/month x 12 months |
| Est volume hauled | 10,767,935 | cy | See assumptions |
| **Est time required for ash removal (months)** | **128** | **months** | **Volume Hauled/ (cy/month)** |
| **Est time required for ash removal (years)** | **10.7** | **years** | **Months/12** |
| **Est Total Trips** | **633,408** | **trips** | **Months x (trips/truck-month) x #Trucks** |
| **Total Est Miles Driven** | **19,002,238** | **Miles** | **Est Trips x Total RT Travel Distance** |
| **Est Miles Driven On Site** | **1,266,816** | **Miles** | **Total Miles x (On-site Distance/Total Distance)** |
| **Est Miles Driven Off Site** | **17,735,422** | **Miles** | **Total Miles x (Off-site Distance/Total Distance)** |
| **Estimate Fuel Consumed (assumed at 5 mpg)** | **3,800,448** | **gallons** | **Total Miles/assumed fuel consumption MPG** |

**Roxboro Ash Basin Closure Project**
**Excavation and Hauling Estimate Work Sheet**
**Roxboro West Ash Basin**
**Prepared By: Scott Auger**

**1/8/2016**

**WAB Closure Option 3 - Closure by Removal (with EAB Landfill Phases 7-9)**

**Key Assumptions Used for Analysis**

| Description | Est Quantity | Units | Notes/Comments |
|---|---|---|---|
| Hauling capacity for on-site disposal: | 17 | cy/truck load (assumed average capacity) | |
| Hauling capacity for off-site disposal: | 17 | cy/truck load (assumed average capacity) | |
| Average time for truck loading/unloading operations: | 20 | minutes | |
| Average speed for on site travel: | 10 | mph | |
| Average speed for off site travel: | 45 | mph | |
| Work shifts: | 1 | shifts | |
| Shift Length | 12 | hours | |
| Average Monthly Work Days | 25 | days/month | |

**Summary of Estimated Quantities**

| Description | Est Quantity | Units | Notes/Comments |
|---|---|---|---|
| Estimated On-Site Travel Distance (1 way): | 1.2 | Miles | |
| Estimated Off-Site Travel Distance (1 way): | 0.0 | Miles | |
| Total Estimated Travel Distance (1 way): | 1.2 | Miles | |
| Total Estimated Travel Distance (RT): | 2.4 | Miles | |
| Estimated Landfill Property Area: | 213 | Acres | |
| Estimated Landfill Development Area (including buffer and borrow area): | 213 | Acres | |
| Estimated Lined Landfill Area: | 86 | Acres | |
| Estimated West Ash Basin Closure Area: | 186 | Acres | |
| Estimated WAB Restoration Area (after ash removal): | 186 | Acres | |
| Estimated Ash Material Removed/Hauled Volume: | 10,382,000 | CY | |
| Estimated Ash Material Removed/Hauled Moist Wt: | 12,458,400 | Tons (bsed on 1.2 Tons/CY Moist Unit Wt) | |
| Estimated Contaminated Soil Removed/Hauled Volume (WAB): | 300,080 | CY | |
| Estimated Contaminated Soil Removed/Hauled Volume (Disch Channel): | 85,855 | CY | |
| Estimated Contaminated Soil Removed/Hauled Moist Wt: | 578,903 | Tons (based on 1.5 Tons/CY Moist Unit Wt) | |
| Total Estimated Ash and Contaminated Soil Removed/Hauled Volume: | 10,767,935 | CY | |
| Total Estimated Ash and Contaminated Soil Removed/Hauled Moist Wt: | 13,037,303 | Tons (based on Moist Unit Wt ) | |
| Total Estimated Ash and Contaminated Soil Placed in Landfill Volume: | 8,614,348 | Tons (based on 0.8 x Volume Hauled ) | |

**Calculation Summary**

| Description | Quantity | Units | Notes/Comments |
|---|---|---|---|
| Est On Site Haul Travel Distance (1 way) | 1 | Miles | See estimated quantities |
| On Site Haul RT Distance | 2 | Miles | Travel Distance x 2 |
| Assumed Avg Speed (on site) | 10 | mph | See assumptions |
| Assumed On Site Travel Time | 0.20 | hr | RT Distance/Avg Speed |
| Est Off Site Haul Distance | 0 | Miles | See estimated quantities |
| Off Site Haul RT Distance | 0 | Miles | Travel Distance x 2 |
| Assumed Avg Speed (off site) | 45 | mph | See assumptions |
| Assumed Off Site Travel Time | 0.00 | hr | RT Distance/Avg Speed |
| Assumed loading/unloading time | 0.33 | hr | See assumptions |
| Total Est Time Each Loading/Hauling/Unloading Operation | 0.53 | hr | Loading Time + Travel time |
| ***Est Haul Truck Fleet Size:*** | ***17*** | ***trucks*** | ***Adjust # vehicles here as needed for travel separation time.*** |
| Est separation time between vehicles: | 2.0 | minutes | Total Travel Time x 60/(# Trucks - 1) - 2 minutes min suggested by Tom Maier for traffic safety |
| Assumed daily hours hauled | 12 | hr | See assumptions |
| Assumed monthly days worked | 25 | days/mo | See assumptions |
| Est monthly hours hauling | 300 | hrs/truck-month | Hours Hauled/day x Days Worked/month |
| Est monthly trips per truck | 563 | trips/truck-month | Hrs/Truck-month/ Total Haul Time |
| Assumed volume per truck | 17 | cy | See assumptions |
| Est volume hauled per truck month | 9,563 | cy/truck month | Load Capacity x Trips/Truck-month |
| Est volume hauled per month (fleet) | 162,563 | cy/month | cy/Truck-month x # Trucks |
| Est volume hauled per year (fleet) | 1,950,750 | cy/year | cy/month x 12 months |
| Est volume hauled | 10,767,935 | cy | See assumptions |
| **Est time required for ash removal (months)** | **66** | **months** | **Volume Hauled/ (cy/month)** |
| **Est time required for ash removal (years)** | **5.5** | **years** | **Months/12** |
| **Est Total Trips** | **633,408** | **trips** | **Months x (trips/truck-month) x #Trucks** |
| **Total Est Miles Driven** | **1,520,179** | **Miles** | **Est Trips x Total RT Travel Distance** |
| **Est Miles Driven On Site** | **1,520,179** | **Miles** | **Total Miles x (On-site Distance/Total Distance)** |
| **Est Miles Driven Off Site** | **0** | **Miles** | **Total Miles x (Off-site Distance/Total Distance)** |
| **Estimate Fuel Consumed (assumed at 5 mpg)** | **304,036** | **gallons** | **Total Miles/assumed fuel consumption MPG** |

**Roxboro Ash Basin Closure Project**
**Excavation and Hauling Estimate Work Sheet**
**Roxboro West Ash Basin**
**Prepared By: Scott Auger**

**1/8/2016**

**WAB Closure Option 4 - Close in Place Hybrid (CAP Concept)**

**Key Assumptions Used for Analysis**

| Description | Est Quantity | Units | Notes/Comments |
|---|---|---|---|
| Hauling capacity for on-site disposal: | 17 | cy/truck load (assumed average capacity) | |
| Hauling capacity for off-site disposal: | 17 | cy/truck load (assumed average capacity) | |
| Average time for truck loading/unloading operations: | 20 | minutes | |
| Average speed for on site travel: | 10 | mph | |
| Average speed for off site travel: | 45 | mph | |
| Work shifts: | 1 | shifts | |
| Shift Length | 12 | hours | |
| Average Monthly Work Days | 25 | days/month | |

**Summary of Estimated Quantities**

| Description | Est Quantity | Units | Notes/Comments |
|---|---|---|---|
| Estimated On-Site Travel Distance (1 way): | 0.5 | Miles | |
| Estimated Off-Site Travel Distance (1 way): | 0.0 | Miles | |
| Total Estimated Travel Distance (1 way): | 0.5 | Miles | |
| Total Estimated Travel Distance (RT): | 1.0 | Miles | |
| Estimated Landfill Property Area: | 0 | Acres | |
| Estimated Landfill Development Area (including buffer and borrow area): | 0 | Acres | |
| Estimated Lined Landfill Area: | 0 | Acres | |
| Estimated West Ash Basin Closure Area: | 186 | Acres | |
| Estimated WAB Restoration Area (after ash removal): | 34 | Acres | |
| Estimated Ash Material Removed/Hauled Volume: | 5,140,645 | CY | |
| Estimated Ash Material Removed/Hauled Moist Wt: | 6,168,774 | Tons (bsed on 1.2 Tons/CY Moist Unit Wt) | |
| Estimated Contaminated Soil Removed/Hauled Volume (WAB): | 175,853 | CY | |
| Estimated Contaminated Soil Removed/Hauled Volume (Disch Channel): | 85,855 | CY | |
| Estimated Contaminated Soil Removed/Hauled Moist Wt: | 392,562 | Tons (based on 1.5 Tons/CY Moist Unit Wt) | |
| Total Estimated Ash and Contaminated Soil Removed/Hauled Volume: | 5,402,353 | CY | |
| Total Estimated Ash and Contaminated Soil Removed/Hauled Moist Wt: | 6,561,336 | Tons (based on Moist Unit Wt ) | |
| Total Estimated Ash and Contaminated Soil Placed in Landfill Volume: | 4,321,882 | Tons (based on 0.8 x Volume Hauled ) | |

**Calculation Summary**

| Description | Quantity | Units | Notes/Comments |
|---|---|---|---|
| Est On Site Haul Travel Distance (1 way) | 1 | Miles | See estimated quantities |
| On Site Haul RT Distance | 2 | Miles | Travel Distance x 2 |
| Assumed Avg Speed (on site) | 10 | mph | See assumptions |
| Assumed On Site Travel Time | 0.20 | hr | RT Distance/Avg Speed |
| Est Off Site Haul Distance | 0 | Miles | See estimated quantities |
| Off Site Haul RT Distance | 0 | Miles | Travel Distance x 2 |
| Assumed Avg Speed (off site) | 45 | mph | See assumptions |
| Assumed Off Site Travel Time | 0.00 | hr | RT Distance/Avg Speed |
| Assumed loading/unloading time | 0.33 | hr | See assumptions |
| Total Est Time Each Loading/Hauling/Unloading Operation | 0.53 | hr | Loading Time + Travel time |
| ***Est Haul Truck Fleet Size:*** | ***17*** | ***trucks*** | ***Adjust # vehicles here as needed for travel separation time.*** |
| Est separation time between vehicles: | 2.0 | minutes | Total Travel Time x 60/(# Trucks - 1) - 2 minutes min suggested by Tom Maier for traffic safety |
| Assumed daily hours hauled | 12 | hr | See assumptions |
| Assumed monthly days worked | 25 | days/mo | See assumptions |
| Est monthly hours hauling | 300 | hrs/truck-month | Hours Hauled/day x Days Worked/month |
| Est monthly trips per truck | 563 | trips/truck-month | Hrs/Truck-month/ Total Haul Time |
| Assumed volume per truck | 17 | cy | See assumptions |
| Est volume hauled per truck month | 9,563 | cy/truck month | Load Capacity x Trips/Truck-month |
| Est volume hauled per month (fleet) | 162,563 | cy/month | cy/Truck-month x # Trucks |
| Est volume hauled per year (fleet) | 1,950,750 | cy/year | cy/month x 12 months |
| Est volume hauled | 5,402,353 | cy | See assumptions |
| **Est time required for ash removal (months)** | **33** | **months** | **Volume Hauled/ (cy/month)** |
| **Est time required for ash removal (years)** | **2.8** | **years** | **Months/12** |
| **Est Total Trips** | **317,785** | **trips** | **Months x (trips/truck-month) x #Trucks** |
| **Total Est Miles Driven** | **317,785** | **Miles** | **Est Trips x Total RT Travel Distance** |
| **Est Miles Driven On Site** | **317,785** | **Miles** | **Total Miles x (On-site Distance/Total Distance)** |
| **Est Miles Driven Off Site** | **0** | **Miles** | **Total Miles x (Off-site Distance/Total Distance)** |
| **Estimate Fuel Consumed (assumed at 5 mpg)** | **63,557** | **gallons** | **Total Miles/assumed fuel consumption MPG** |

**Roxboro Ash Basin Closure Project**
**Excavation and Hauling Estimate Work Sheet**
**Roxboro West Ash Basin**
**Prepared By: Scott Auger**

**1/8/2016**

**WAB Closure Option 5 - Close in Place Hybrid (Minimum Excavation)**

**Key Assumptions Used for Analysis**

| Description | Est Quantity | Units | Notes/Comments |
|---|---|---|---|
| Hauling capacity for on-site disposal: | 17 | cy/truck load (assumed average capacity) | |
| Hauling capacity for off-site disposal: | 17 | cy/truck load (assumed average capacity) | |
| Average time for truck loading/unloading operations: | 20 | minutes | |
| Average speed for on site travel: | 10 | mph | |
| Average speed for off site travel: | 45 | mph | |
| Work shifts: | 1 | shifts | |
| Shift Length | 12 | hours | |
| Average Monthly Work Days | 25 | days/month | |

**Summary of Estimated Quantities**

| Description | Est Quantity | Units | Notes/Comments |
|---|---|---|---|
| Estimated On-Site Travel Distance (1 way): | 0.7 | Miles | |
| Estimated Off-Site Travel Distance (1 way): | 0.0 | Miles | |
| Total Estimated Travel Distance (1 way): | 0.7 | Miles | |
| Total Estimated Travel Distance (RT): | 1.4 | Miles | |
| Estimated Landfill Property Area: | 0 | Acres | |
| Estimated Landfill Development Area (including buffer and borrow area): | 0 | Acres | |
| Estimated Lined Landfill Area: | 186 | Acres | |
| Estimated West Ash Basin Closure Area: | 186 | Acres | |
| Estimated WAB Restoration Area (after ash removal): | 0 | Acres | |
| Estimated Ash Material Removed/Hauled Volume: | 1,314,364 | CY | |
| Estimated Ash Material Removed/Hauled Moist Wt: | 1,577,237 | Tons (bsed on 1.2 Tons/CY Moist Unit Wt) | |
| Estimated Contaminated Soil Removed/Hauled Volume (WAB): | 0 | CY | |
| Estimated Contaminated Soil Removed/Hauled Volume (Disch Channel): | 85,855 | CY | |
| Estimated Contaminated Soil Removed/Hauled Moist Wt: | 128,783 | Tons (based on 1.5 Tons/CY Moist Unit Wt) | |
| Total Estimated Ash and Contaminated Soil Removed/Hauled Volume: | 1,400,219 | CY | |
| Total Estimated Ash and Contaminated Soil Removed/Hauled Moist Wt: | 1,706,019 | Tons (based on Moist Unit Wt ) | |
| Total Estimated Ash and Contaminated Soil Placed in Landfill Volume: | 1,120,175 | Tons (based on 0.8 x Volume Hauled ) | |

**Calculation Summary**

| Description | Quantity | Units | Notes/Comments |
|---|---|---|---|
| Est On Site Haul Travel Distance (1 way) | 0.7 | Miles | See estimated quantities |
| On Site Haul RT Distance | 1.4 | Miles | Travel Distance x 2 |
| Assumed Avg Speed (on site) | 10 | mph | See assumptions |
| Assumed On Site Travel Time | 0.14 | hr | RT Distance/Avg Speed |
| Est Off Site Haul Distance | 0 | Miles | See estimated quantities |
| Off Site Haul RT Distance | 0 | Miles | Travel Distance x 2 |
| Assumed Avg Speed (off site) | 45 | mph | See assumptions |
| Assumed Off Site Travel Time | 0.00 | hr | RT Distance/Avg Speed |
| Assumed loading/unloading time | 0.33 | hr | See assumptions |
| Total Est Time Each Loading/Hauling/Unloading Operation | 0.47 | hr | Loading Time + Travel time |
| ***Est Haul Truck Fleet Size:*** | ***15*** | ***trucks*** | ***Adjust # vehicles here as needed for travel separation time.*** |
| Est separation time between vehicles: | 2.0 | minutes | Total Travel Time x 60/(# Trucks - 1) - 2 minutes min suggested by Tom Maier for traffic safety |
| Assumed daily hours hauled | 12 | hr | See assumptions |
| Assumed monthly days worked | 25 | days/mo | See assumptions |
| Est monthly hours hauling | 300 | hrs/truck-month | Hours Hauled/day x Days Worked/month |
| Est monthly trips per truck | 634 | trips/truck-month | Hrs/Truck-month/ Total Haul Time |
| Assumed volume per truck | 17 | cy | See assumptions |
| Est volume hauled per truck month | 10,775 | cy/truck month | Load Capacity x Trips/Truck-month |
| Est volume hauled per month (fleet) | 161,620 | cy/month | cy/Truck-month x # Trucks |
| Est volume hauled per year (fleet) | 1,939,437 | cy/year | cy/month x 12 months |
| Est volume hauled | 1,400,219 | cy | See assumptions |
| **Est time required for ash removal (months)** | **9** | **months** | **Volume Hauled/ (cy/month)** |
| **Est time required for ash removal (years)** | **0.7** | **years** | **Months/12** |
| **Est Total Trips** | **82,366** | **trips** | **Months x (trips/truck-month) x #Trucks** |
| **Total Est Miles Driven** | **115,312** | **Miles** | **Est Trips x Total RT Travel Distance** |
| **Est Miles Driven On Site** | **115,312** | **Miles** | **Total Miles x (On-site Distance/Total Distance)** |
| **Est Miles Driven Off Site** | **0** | **Miles** | **Total Miles x (Off-site Distance/Total Distance)** |
| **Estimate Fuel Consumed (assumed at 5 mpg)** | **23,062** | **gallons** | **Total Miles/assumed fuel consumption MPG** |

**Roxboro Ash Basin Closure Project**
**Excavation and Hauling Estimate Work Sheet**
**Roxboro West Ash Basin**
**Prepared By: Scott Auger**

**1/8/2016**

**WAB Closure Option 6 - Close in Place Hybrid (Combination Close in Place/Landfill)**

**Key Assumptions Used for Analysis**

| Description | Est Quantity | Units | Notes/Comments |
|---|---|---|---|
| Hauling capacity for on-site disposal: | 17 | cy/truck load (assumed average capacity) | |
| Hauling capacity for off-site disposal: | 17 | cy/truck load (assumed average capacity) | |
| Average time for truck loading/unloading operations: | 20 | minutes | |
| Average speed for on site travel: | 10 | mph | |
| Average speed for off site travel: | 45 | mph | |
| Work shifts: | 1 | shifts | |
| Shift Length | 12 | hours | |
| Average Monthly Work Days | 25 | days/month | |

**Summary of Estimated Quantities**

| Description | Est Quantity | Units | Notes/Comments |
|---|---|---|---|
| Estimated On-Site Travel Distance (1 way): | 1.1 | Miles | |
| Estimated Off-Site Travel Distance (1 way): | 0.0 | Miles | |
| Total Estimated Travel Distance (1 way): | 1.1 | Miles | |
| Total Estimated Travel Distance (RT): | 2.2 | Miles | |
| Estimated Landfill Property Area: | 0 | Acres | |
| Estimated Landfill Development Area (including buffer and borrow area): | 102 | Acres | |
| Estimated Lined Landfill Area: | 41 | Acres | |
| Estimated West Ash Basin Closure Area: | 186 | Acres | |
| Estimated WAB Restoration Area (after ash removal): | 77 | Acres | |
| Estimated Ash Material Removed/Hauled Volume: | 5,140,645 | CY | |
| Estimated Ash Material Removed/Hauled Moist Wt: | 6,168,774 | Tons (bsed on 1.2 Tons/CY Moist Unit Wt) | |
| Estimated Contaminated Soil Removed/Hauled Volume (WAB): | 175,853 | CY | |
| Estimated Contaminated Soil Removed/Hauled Volume (Disch Channel): | 85,855 | CY | |
| Estimated Contaminated Soil Removed/Hauled Moist Wt: | 392,562 | Tons (based on 1.5 Tons/CY Moist Unit Wt) | |
| Total Estimated Ash and Contaminated Soil Removed/Hauled Volume: | 5,402,353 | CY | |
| Total Estimated Ash and Contaminated Soil Removed/Hauled Moist Wt: | 6,561,336 | Tons (based on Moist Unit Wt ) | |
| Total Estimated Ash and Contaminated Soil Placed in Landfill Volume: | 4,321,882 | Tons (based on 0.8 x Volume Hauled ) | |

**Calculation Summary**

| Description | Quantity | Units | Notes/Comments |
|---|---|---|---|
| Est On Site Haul Travel Distance (1 way) | 1 | Miles | See estimated quantities |
| On Site Haul RT Distance | 2 | Miles | Travel Distance x 2 |
| Assumed Avg Speed (on site) | 10 | mph | See assumptions |
| Assumed On Site Travel Time | 0.20 | hr | RT Distance/Avg Speed |
| Est Off Site Haul Distance | 0 | Miles | See estimated quantities |
| Off Site Haul RT Distance | 0 | Miles | Travel Distance x 2 |
| Assumed Avg Speed (off site) | 45 | mph | See assumptions |
| Assumed Off Site Travel Time | 0.00 | hr | RT Distance/Avg Speed |
| Assumed loading/unloading time | 0.33 | hr | See assumptions |
| Total Est Time Each Loading/Hauling/Unloading Operation | 0.53 | hr | Loading Time + Travel time |
| ***Est Haul Truck Fleet Size:*** | ***17*** | ***trucks*** | ***Adjust # vehicles here as needed for travel separation time.*** |
| Est separation time between vehicles: | 2.0 | minutes | Total Travel Time x 60/(# Trucks - 1) - 2 minutes min suggested by Tom Maier for traffic safety |
| Assumed daily hours hauled | 12 | hr | See assumptions |
| Assumed monthly days worked | 25 | days/mo | See assumptions |
| Est monthly hours hauling | 300 | hrs/truck-month | Hours Hauled/day x Days Worked/month |
| Est monthly trips per truck | 563 | trips/truck-month | Hrs/Truck-month/ Total Haul Time |
| Assumed volume per truck | 17 | cy | See assumptions |
| Est volume hauled per truck month | 9,563 | cy/truck month | Load Capacity x Trips/Truck-month |
| Est volume hauled per month (fleet) | 162,563 | cy/month | cy/Truck-month x # Trucks |
| Est volume hauled per year (fleet) | 1,950,750 | cy/year | cy/month x 12 months |
| Est volume hauled | 5,402,353 | cy | See assumptions |
| **Est time required for ash removal (months)** | **33** | **months** | **Volume Hauled/ (cy/month)** |
| **Est time required for ash removal (years)** | **2.8** | **years** | **Months/12** |
| **Est Total Trips** | **317,785** | **trips** | **Months x (trips/truck-month) x #Trucks** |
| **Total Est Miles Driven** | **699,128** | **Miles** | **Est Trips x Total RT Travel Distance** |
| **Est Miles Driven On Site** | **699,128** | **Miles** | **Total Miles x (On-site Distance/Total Distance)** |
| **Est Miles Driven Off Site** | **0** | **Miles** | **Total Miles x (Off-site Distance/Total Distance)** |
| **Estimate Fuel Consumed (assumed at 5 mpg)** | **139,826** | **gallons** | **Total Miles/assumed fuel consumption MPG** |

Roxboro Closure Options Evaluation
Duke Energy
Amec Foster Wheeler Project No. 7810150347
ATTACHMENTS

- WAB Closure Options Evalaution Workbook

# Scoring for Evaluation of Closure Options
## Closure Options Evaluation Worksheet
## Roxboro Ash Basin Closure Project - Roxboro West Ash Basin (WAB)
## Duke Energy

**Draft Rev. 0**
**Site Name: Roxboro Station**
**Date: 1-8-2016**

| | |
|---|---|
| 1 | = Option-Specific User Input |
| 1 | = Calculated Value |

Placeholder values have been entered in "User Input" cells to prevent division by zero error text in calculated score cells.

| Threshold Criteria: All closure options must comply with the following threshold criteria based on Duke Energy Guiding Principals for Ash Basin Closure |
|---|
| 1. Provide continued geotechnical stability meeting appropriate safety factors under applicable loading conditions |
| 2. Provide flow capacity and erosion resistance during design storm and flooding conditions |
| 3. Effectively mitigate groundwater impacts (in conjunction with GW remediation where present) |
| 4. Comply with applicable state and federal regulations (e.g. North Carolina Coal Ash Management Act) |

| Option | Description |
|---|---|
| 1 | WAB Option 1 - Closure by Removal (with On-site Landfill) |
| 2 | WAB Option 2 - Closure by Removal (with Off-site Landfill) |
| 3 | WAB Option 3 - Closure by Removal (with EAB Landfill Phases 7-9) |
| 4 | WAB Option 4 - Close in Place Hybrid Option (Partial Removal and Capping) |
| 5 | WAB Option 5 - Close in Place Hybrid Option (with Minimum Excavation) |
| 6 | WAB Option 6 - Hybrid Closure (Combination of Close in Place/Landfill) |
| A | WAB Option A - Hybrid Closure (with New Landfill located in WAB) |

Note: Options that did not meet threshold criteria should be listed in the Options Summary table above for completeness

| Environmental Protection and Impacts | Weight: | 30% | | User Input | | | | | | Value that Scores | Value that Scores | Calculated or User Selected Score | | | | | | Criterion | Contribution to |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Criterion | Scoring System | Required Input | Units | Option 1 | Option 2 | Option 3 | Option 4 | Option 5 | Option 6 | 10 | 0 | Option 1 | Option 2 | Option 3 | Option 4 | Option 5 | Option 6 | Weight | Total Score |
| Time to achieve compliance with groundwater standards at compliance boundary | Interpolation. Minimum value scores 10. | Compliance time | Years | 12 | 18.2 | 12 | 7.5 | 5.5 | 9.3 | 5.5 | 18.2 | 5 | 0 | 5 | 8 | 10 | 7 | 15% | 4.5% |
| Residual groundwater-related risk | Source removed=10<br>Source above GW=5<br>Source below GW=0<br>Conduits remain=1 | This Area Not Used For Subjective Scoring | | | | | | | | | | 10 | 10 | 10 | 1 | 0 | 1 | 20% | 6.0% |
| Proximity to Hyco Lake | Interpolation. Maximum value scores 10 | Distance from CCR Unit limit | Miles | 0.1 | 15 | 0.1 | 0.1 | 0.1 | 0.1 | 15 | 0.1 | 0 | 10 | 0 | 0 | 0 | 0 | 10% | 3.0% |
| Proximity to public drinking water intakes (No intakes idneified) | Interpolation. Maximum value scores 10 | Downgradient distance to intake | Miles | | | | | | | 0 | 0 | | | | | | | 0% | 0.0% |
| Proximity to nearest downgradient potable water well (no downgradient wells identified) | Interpolation. Maximum value scores 10 | Downgradient distance to nearest well | Miles | | | | | | | 0 | 0 | | | | | | | 0% | 0.0% |
| Proximity to flora, fauna and human receptors | Subjective 0 to 10 (0 - potential for GW seepage from WAB ash deposit, 10 - No potential GW contact. | This Area Not Used For Subjective Scoring | | | | | | | | | | 10 | 10 | 10 | 1 | 0 | 1 | 5% | 1.5% |
| Restoration of habitat, streams or wetlands | Interpolation. Maximum value scores 10. | Habitat and wetlands acres or stream length | Acres | 186 | 186 | 186 | 109 | 0 | 109 | 186 | 0 | 10 | 10 | 10 | 6 | 0 | 6 | 20% | 6.0% |
| Air emissions off-site (based on miles driven ) | Interpolation. Zero miles scores 10. | Truck miles driven | Miles | 0 | 17735422 | 0 | 0 | 0 | 0 | 0 | 17735422 | 10 | 0 | 10 | 10 | 10 | 10 | 5% | 1.5% |
| Air emissions on-site from closure implementation (based on miles driven) | Interpolation. Zero gallons scores 10. | Truck miles driven | Miles | 1266816 | 1266816 | 1520179 | 317785 | 115312 | 699128 | 115312 | 1520179 | 2 | 2 | 0 | 9 | 10 | 6 | 5% | 1.5% |
| Avoidance of greenfield disturbance | Interpolation. Zero acres scores 10. | Disturbed acres of greenfield | Acres | 213 | 250 | 213 | 0 | 0 | 106 | 0 | 250 | 1 | 0 | 1 | 10 | 10 | 6 | 20% | 6.0% |
| **Weighted Totals (Contribution to Total Score)** | | | | | | | | | | | | **1.8** | **1.7** | **1.8** | **1.7** | **1.4** | **1.4** | 100% | |

| Cost | Weight: | 35% | | User Input | | | | | | Value that Scores | Value that Scores | Calculated or User Selected Score | | | | | | Criterion | Contribution to |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Criterion | Scoring System | Required Input | Units | Option 1 | Option 2 | Option 3 | Option 4 | Option 5 | Option 6 | 10 | 0 | Option 1 | Option 2 | Option 3 | Option 4 | Option 5 | Option 6 | Weight | Total Score |
| Closure Cost | Interpolation. Min value scores 10. Max value scores 0. | Closure Cost | Million $ | $160.5 | $267.5 | $169.2 | $95.4 | $79.2 | $157.6 | $ 79.20 | $ 267.50 | 5.7 | 0.0 | 5.2 | 9.1 | 10.0 | 5.8 | 80% | 28.0% |
| Operation, Maintenance and Monitoring Cost (Evalluated for 30 years) | | OM&M Cost | Million $ | $6.1 | $7.0 | $6.1 | $5.7 | $11.2 | $9.5 | $ 5.67 | $ 11.23 | 9.2 | 7.6 | 9.2 | 10.0 | 0.0 | 3.1 | 20% | 7.0% |

# Scoring for Evaluation of Closure Options
## Closure Options Evaluation Worksheet
## Roxboro Ash Basin Closure Project - Roxboro West Ash Basin (WAB)
## Duke Energy

**Draft Rev. 0**
**Site Name: Roxboro Station**
**Date: 1-8-2016**

| | |
|---|---|
| 1 | = Option-Specific User Input |
| 1 | = Calculated Value |

Placeholder values have been entered in "User Input" cells to prevent division by zero error text in calculated score cells.

| Weighted Totals (Contribution to Total Score) | | | | | | | | | | | 2.2 | 0.5 | 2.1 | 3.2 | 2.8 | 1.8 | 100% | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Schedule** | **Weight:** | **15%** | | **User Input** | | | | | | **Value that Scores** | **Value that Scores** | **Calculated or User Selected Score** | | | | | | **Criterion** | **Contribution to** |
| **Criterion** | **Scoring System** | **Required Input** | **Units** | **Option 1** | **Option 2** | **Option 3** | **Option 4** | **Option 5** | **Option 6** | **10** | **0** | **Option 1** | **Option 2** | **Option 3** | **Option 4** | **Option 5** | **Option 6** | **Weight** | **Total Score** |
| Initiation Time | Interpolation Minimum value scores 10 | Time to move first ash | Months | 52 | 75 | 52 | 21 | 21 | 40 | 21 | 75 | 4 | 0 | 4 | 10 | 10 | 6 | 30% | 4.5% |
| Project Duration (to completion of closure) | Interpolation Minimum value scores 10 | Estimated durations | Months | 142 | 228 | 142 | 92 | 98 | 105 | 92 | 228 | 6 | 0 | 6 | 10 | 10 | 9 | 70% | 10.5% |
| **Weighted Totals (Contribution to Total Score)** | | | | | | | | | | | | **0.8** | **0.0** | **0.8** | **1.5** | **1.5** | **1.2** | 100% | |
| **Regional Factors** | **Weight:** | **15%** | | **User Input** | | | | | | **Value that Scores** | **Value that Scores** | **Calculated or User Selected Score** | | | | | | **Criterion** | **Contribution to** |
| **Criterion** | **Scoring System** | **Required Input** | **Units** | **Option 1** | **Option 2** | **Option 3** | **Option 4** | **Option 5** | **Option 6** | **10** | **0** | **Option 1** | **Option 2** | **Option 3** | **Option 4** | **Option 5** | **Option 6** | **Weight** | **Total Score** |
| Plan or potential for beneficial reuse of site | Subjective | Not Used For Subjective Scoring | | | | | | | | | | 10 | 10 | 10 | 5 | 0 | 8 | 5% | 0.8% |
| Imported soil needs | Interpolation Min value scores 10 Max value scores 0 | Soil Imported | CY | 277493 | 332347 | 277493 | 782972 | 600160 | 921081 | 277493 | 921081 | 10 | 9 | 10 | 2 | 5 | 0 | 5% | 0.8% |
| Beneficial reuse of CCR (not considered applicable) | Interpolation. Maximum value scores 10. | Fraction Used | None | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | | | | | | 0% | 0.0% |
| Transportation impact (based on miles driven) - Note that value (miles driven) for Option 2 based on 2 x Option 3 to avoid skewing ranking. | Interpolation Min value scores 10 Max value scores 0 | Miles Driven | Miles | 1266816 | 3040358 | 1520179 | 317785 | 115312 | 699128 | 115312 | 3040358 | 6 | 0 | 5 | 9 | 10 | 8 | 65% | 9.8% |
| Noise impact due to on-site activity (based on proximity of neighbors to on-site work areas) | Subjective 0 to 10 | Not Used For Subjective Scoring | | | | | | | | | | 8 | 0 | 6 | 10 | 9 | 7 | 5% | 0.8% |
| View impact (based on final height of storage facility and land uses within viewshed) | Subjective 0 to 10 | | | | | | | | | | | 5 | 0 | 5 | 5 | 10 | 8 | 20% | 3.0% |
| **Weighted Totals (Contribution to Total Score)** | | | | | | | | | | | | **0.9** | **0.1** | **0.8** | **1.2** | **1.4** | **1.1** | 100% | 15% |
| **Constructability** | **Weight:** | **5%** | | **User Input** | | | | | | **Value that Scores** | **Value that Scores** | **Calculated or User Selected Score** | | | | | | | |
| **Criterion** | **Scoring System** | **Required Input** | **Units** | **Option 1** | **Option 2** | **Option 3** | **Option 4** | **Option 5** | **Option 6** | **10** | **0** | **Option 1** | **Option 2** | **Option 3** | **Option 4** | **Option 5** | **Option 6** | | |
| Consider stormwater management, geotechnical, and dewatering | Subjective 0 to 10: 10 is the easiest while 0 is the riskiest | Not Used For Subjective Scoring | | | | | | | | | | 3 | 0 | 3 | 8 | 10 | 5 | 100% | 5.0% |
| **Weighted Totals (Contribution to Total Score)** | | | | | | | | | | | | **0.2** | **0.0** | **0.2** | **0.4** | **0.5** | **0.3** | | |
| **Total Score For Each Option (On a Scale of 0 to 10)** | | | | | | | | | | | | **6.0** | **2.4** | **5.7** | **8.0** | **7.5** | **5.8** | | |

Roxboro Closure Options Evaluation
Duke Energy
Amec Foster Wheeler Project No. 7810150347
ATTACHMENTS

East Ash Basin (EAB) Attachments

Roxboro Closure Options Evaluation
Duke Energy
Amec Foster Wheeler Project No. 7810150347
ATTACHMENTS

- Table 1(EAB) – East Ash Basin Closure Options Summary (evaluation on hold)

Draft Rev 0 (1-8-16)

**Amec Foster Wheeler**
**Table 1(EAB) – Closure Option Summary (Identification of Options)**
**Feasibility Analyses - Ash Basin Closure Conceptual Design**
**Roxboro Steam Station East Ash Basin (EAB)**

| Option | Description |
|---|---|
| 1. Close in Place Hybrid Option (with Completion of Phases 1-6) | This closure option will consist of consolidating and capping the ash deposits located outside the limits of the currently permitted/lined landfill area (Phases 1-6). For this option, it is assumed that the existing permitted/lined landfill area (Phases 1-6) will be completed as planned but Phases 7-9 would not be developed. This option evaluates only the closure requirements for ash fill areas outside the limits of Phases 1-6. The evaluation does not include the requirements for completion of Phases 1-6 or development of another landfill to support plant operations. |
| 2. Close in Place Hybrid Option (with Completion of Phases 7-9) | This closure option assumes that the currently permitted and lined landfill area will be expanded to provide capacity for future ash storage based on the preliminary Phases 7-9 plan. The remaining ash fill areas outside the limits of the expanded landfill area would be closed by capping with an engineered cover system. This option evaluates only the closure requirements outside the limits of Phases 1-6 and Phases 7-9. The evaluation does not include the requirements for completion of Phases 1-6 or development of Phases 7-9. |
| A. Closure by Removal Option<br><br>NOT EVALUATED | The authorized scope of services for Amec Foster Wheeler is supposed to cover only the closure options associated with ash fill areas outside the limits of the currently permitted and lined landfill area (assumed to be Phases 1-6). During the November 12, 2015, Duke Energy confirmed that consideration of a Closure by Removal Option will not be required |

# Robinson Ash Basin Closure Investigation

Conceptual Closure Planning Update

*H.B Robinson Steam Electric Plant, Darlington County, SC*

**December 2014**

# Contents

**APPENDICES**

## Figures



## Tables

# Executive Summary

The purpose of this Conceptual Closure Planning document is to present South Carolina Department of Health and Environmental Control (SCDHEC) with an update of Duke Energy's progress to date on the Robinson Ash Basin Closure Investigation and describe future work activities that will support development of a preferred ash basin closure plan.

Duke Energy conducted a geotechnical and environmental exploration program in and around the H.B. Robinson Steam Electric Plant (Robinson Plant) Unit 1 ash basin and 1960 Fill Area (collectively referred to as the ash management areas) between July and November 2014. The program consisted of soil borings, groundwater monitoring well installation, testing of soil, ash, groundwater and free water, and in-situ hydraulic conductivity testing. A summary of data and information collected as part of the geotechnical and environmental exploration program, along with a summary of results, is provided in this update report. A more detailed description of data collected, methodologies used, and testing results is provided in the companion Robinson Ash Basin Closure Investigation Data Report (HDR 2014).

The data derived from the field investigation program is being evaluated to achieve the following project objectives:

- Determine the amount of coal ash residue in the ash basin and 1960 Fill Area
- Characterize subsurface material within the ash management areas, down-gradient of the ash basin, and in background areas of the site
- Develop a Site Conceptual Model (SCM) to serve as the basis for understanding the hydrogeologic characteristics of the site and ash basin (both existing and under the preferred closure option)
- Use the SCM to develop a conceptual closure plan for the ash management areas that is protective of human health and the environment and acceptable to SCDHEC Bureau of Water

Three potential permanent ash basin closure options are being considered:

- **Hybrid Cap-in-Place** whereby coal ash residue from the 1960 Fill Area would be excavated and placed into the ash basin, ash immediately behind the ash basin embankment would be moved farther west within the basin to allow breaching or removal of the embankment, and consolidated ash within the basin would be capped with an engineered cover system. Potential areas of saturated ash within the basin post-closure (based on SCM modeling) would be reduced or eliminated using appropriate engineering measures (e.g., removal of ash from saturated areas, fixing ash in place via soil mixing and/or injection of stabilizing materials, installation of infiltration cut-off walls on the upstream side of the ash basin, etc.) to prevent or minimize leaching of coal ash constituents to down-gradient areas.
- **On-Site Landfill** whereby coal ash residue from the 1960 Fill Area and ash basin would be excavated and moved to a lined landfill designed to contain coal ash residue. While not thoroughly investigated at this time, an on-site landfill could potentially be located on

the northwest side of Duke Energy's H.B. Robinson/Darlington Electric Power Plant (Darlington County Plant).

- **Off-Site Landfill** whereby coal ash residue from the 1960 Fill Area and ash basin would be excavated and hauled to a lined landfill designed and permitted to receive coal ash residue. This could either be an existing lined landfill with capacity and ability to accept the coal ash residue or a newly constructed lined landfill permitted to accept coal ash residue.

Based on data and information collected between July and November 2014, it appears that up to 18 feet of ash is saturated in the deepest portion of the ash basin (between the transmission line right-of-way and the ash basin embankment). Additional groundwater data collection and completion of a post-closure groundwater model is necessary to precisely predict the post-closure long-term groundwater level in the ash and whether additional mitigation measures are necessary to protect groundwater. This post-closure model will serve to inform decision-making on the three options described above. While the saturated depth of ash diminishes moving away from this area, it is uncertain at this time if the Hybrid Cap-in-Place closure method will reduce the amount of saturated ash in the basin to a point where this option becomes viable.

Further evaluation of data is on-going in support of the development of a preferred closure option. To that end, Duke Energy intends to perform the following work:

- Conduct further analyses of the foundation soils at the ash basin and embankment, for the Hybrid Cap-in-Place option, to determine susceptibility to liquefaction of in-situ soils during seismic events. Such liquefaction could result in differential settlement of a liner or cap and/or induced embankment failure. Analyses may consist of, but would not be limited to, laboratory cyclic triaxial testing of remolded soil samples conducted in conjunction with additional in-situ soil testing. These studies and follow-up finite element analysis will help determine engineering remedies for mitigating potential liquefaction induced differential settlements. The analyses will also be used to develop design criteria for static and post-seismic embankment stability.
- Evaluate potential impacts to the ash basin embankment and ash basin resulting from a postulated 100-year flood event and determine engineering remedies to mitigate for potential impacts
- Evaluate laboratory results from in-basin, near-basin, and background sample locations to determine site-specific coal ash residue constituents of concern
- Develop calculations to evaluate the potential for leaching of coal ash residue constituents of concern from ash into the groundwater
- Conduct three additional rounds of groundwater sampling between January and August 2015 to evaluate potential seasonal variations in groundwater quality data and groundwater surface elevations
- Complete groundwater fate and transport modeling of site-specific coal ash residue constituents of concern to evaluate mobility and concentration gradients over time and evaluate post-closure groundwater elevations in the ash basin as it relates to potential additional groundwater protection measures

The above work activities will be used to evaluate Hybrid Cap-in-Place as a permanent ash basin closure option. If Hybrid Cap-in-Place is not a suitable closure option, the On-Site and Off-Site Landfill closure options will be further investigated to determine which of these options is preferred.

Duke Energy intends to submit a detailed Supplemental Conceptual Closure Plan to SCDHEC Bureau of Water by November 20, 2015. This supplement will provide the analysis for and recommend a preferred permanent closure option for the Robinson Plant ash basin.

# 1.0 Introduction

## 1.1 Project Overview

Duke Energy Progress (Duke Energy) owns and operates the H.B. Robinson Steam Electric Plant (Robinson Plant) located near Hartsville in Darlington County, South Carolina (**Figure 1**). The Robinson Plant coal ash management facilities include a former 177-megawatt coal-fired unit (Unit 1), one ash basin located north of the Robinson Plant and west of Lake Robinson, and an older ash storage area (1960 Fill Area) located west of Unit 1 (**Figure 2**). Coal ash residue generated during the coal combustion process at Unit 1 was stored in the 1960 Fill Area from 1960 until the mid-1970s when the approximate 72-acre ash basin was constructed. The ash basin continued to receive coal ash residue until October 2012 when Unit 1 was retired.

Duke Energy retained HDR to develop a Conceptual Closure Plan (Plan) for the Robinson Plant ash basin. To do so, HDR implemented a geotechnical and environmental exploration program between July and November 2014 that consisted of soil boring completion; monitoring well installation; index property testing of soil and ash; constituent testing of soil, ash, groundwater, and free water; and in-situ hydraulic conductivity testing. The data derived from the field program is being evaluated to achieve the following project objectives:

- Determine the amount of coal ash residue in the ash basin and 1960 Fill Area
- Characterize subsurface materials within the ash management areas, down-gradient of the ash basin, and in background areas of the site
- Develop a Site Conceptual Model (SCM) to serve as the basis for understanding the hydrogeologic characteristics of the site and ash basin (both existing and under the preferred closure option)
- Use the SCM to develop a conceptual plan for closure of the ash basin that is protective of human health and the environment and acceptable to SCDHEC Bureau of Water per their guidance *Proper Closeout of Wastewater Treatment Facilities*, *Regulation 61-82*, dated April 11, 1980

The subsurface investigation included completion of 22 environmental soil borings; 11 geotechnical soil borings; installation of 30 groundwater monitoring wells; and subsequent soil, ash, groundwater, and free water sample collection and testing. Soil boring and monitoring well locations are shown on **Figure 3**. Specific details regarding the field exploration program are provided in Section 3.0 of this report.

Closure of the 1960 Fill Area will be regulated under a Consent Agreement between Duke Energy and the SCDHEC Bureau of Solid Waste. However, the final disposition of ash within the 1960 Fill Area will likely be incorporated into closure of the ash basin and is therefore discussed herein.

## 1.2 Purpose

The purpose of this Conceptual Closure Planning document is to present SCDHEC with an update of Duke Energy's progress to date on the Robinson Ash Basin Closure Investigation and describe future work activities that will support development of a preferred ash basin closure plan. A summary of data and information collected as part of the Robinson Ash Basin Closure Investigation, along with a summary of results, is provided in this update report. A more detailed description of data collected, methodologies used, and testing results is provided in the companion Robinson Ash Basin Closure Investigation Data Report (HDR 2014).

## 1.3 Report Organization

The report is organized into the following sections:

- Site background, geology, and hydrogeology are provided in Section 2.0
- A summary of the geotechnical and environmental exploration programs is provided in Section 3.0
- Results obtained from the exploration program are provided in Section 4.0
- A review of work completed and pending work is provided in Section 5.0
- Potential closure options are summarized in Section 6.0
- A schedule for refinement of the Plan is provided in Section 7.0
- References are provided in Section 8.0

# 2.0 Site Background

## 2.1 Plant Description

The Robinson Plant is a former coal-fired electricity generating facility located approximately 4.5 miles north of Hartsville, Darlington County, South Carolina. The site is bounded by Icy Street to the north, West Old Camden Road to the south, Lake Robinson to the east, and South Carolina Highway 151/West Bobo Newsome Highway to the west.

Development of the Robinson Plant facility began in the late 1950s when Black Creek was impounded to create Lake Robinson. Shortly thereafter, the coal-fired unit (Unit 1) began commercial operation in 1960 until it was retired in October 2012. The 724-megawatt nuclear unit (Unit 2) was brought online in 1971. Duke Energy also owns and operates the H.B. Robinson/Darlington Electric Power Plant (Darlington County Plant) which is located just north of the Robinson Plant and along the western shore of Lake Robinson. The 790-megawatt Darlington County Plant consists of 13 combustion-turbine units fueled by natural gas and oil.

## 2.2 Ash Management Facilities

The Robinson Plant coal ash management facilities include the coal-fired unit (Unit 1), one ash basin located north of the fossil and nuclear units, and the 1960 Fill Area located west of Units 1 and 2 (**Figure 2**).

The 1960 Fill Area was created in 1960 and received ash from Unit 1 until the ash basin was constructed in the mid-1970s. Between May 2013 and August 2014, Duke Energy contracted AMEC Environment & Infrastructure, Inc. (AMEC) to evaluate the extent and volume of ash stored in this area. Based on data obtained during this assessment, ash was found to cover a surficial area of approximately 25.0 acres with a maximum ash thickness of 16.3 feet. The calculated volume of ash within the 1960 Fill Area is 275,800 cubic yards (cy) (AMEC 2014).

The 72-acre ash basin is comprised of a 49-acre basin and a 23-acre dry ash storage area near the upstream (e.g., western) end of the ash basin. The basin was formed via construction of a dam across an unnamed tributary to Black Creek. The basin began receiving sluiced ash from Unit 1 in the mid-1970s, and continued to receive sluiced ash until Unit 1 was retired in October 2012. Based on data obtained during the current exploration program, ash thickness within the basin ranges from 11 feet along the northern flank of the basin to 53 feet in the middle of the basin. Ash thickness is expected to be greatest within the thalweg (i.e., deepest portion of the channel) of the former tributary to Black Creek.

There are no permitted National Pollutant Discharge Elimination System (NPDES) outfalls from the basin to Lake Robinson. However, the ash basin does have a permitted NPDES outfall to the discharge canal located northeast of the basin. In 2014, Duke Energy submitted an NPDES permit application update to re-route stormwater to the discharge canal. The basin also receives discharge from the Darlington County Plant oil/water separator. There is currently no standing water in the 1960 Fill Area or the ash basin, except for the northeastern most corner of the basin where the basin receives discharge from the Darlington County Plant.

## 2.3 Regional Geology/Hydrogeology

South Carolina is divided into distinct regions by portions of three physiographic provinces: the Atlantic Coastal Plain, Piedmont, and Blue Ridge (Fenneman 1938). The Coastal Plain is a region of broad, relatively flat terraces of primarily unconsolidated sediments and carbonate rocks. These materials, ranging in age from Cretaceous to Quaternary, were deposited in shallow seas by rivers draining the Blue Ridge and Piedmont provinces.

Within the upper Coastal Plain and extending across the middle of South Carolina is a narrow, irregular band of rolling hills known as the Carolina Sandhills. These rounded, gently sloping hills range in elevation from 250 to 450 feet above sea level and are generally higher than either the adjacent Piedmont or Coastal Plain regions. The Sandhills region varies in width from 5 to 30 miles, although it is absent along some large river systems such as the Congaree River near Columbia, South Carolina, where it has cut completely through the Sandhills deposits to expose the underlying Piedmont rocks.

The Robinson Plant is located within the Pee Dee area of South Carolina. According to the "Preliminary Assessment of the Groundwater in Part of the Pee Dee Region, South Carolina" (SCDHEC 2003), aquifer systems beneath the Pee Dee Region are primarily Late Cretaceous in age and include the Black Creek, Middendorf, and Cape Fear systems. Groundwater is the principal source of potable water in the Pee Dee region and the Middendorf and Middendorf/Cape Fear systems together are the primary source of groundwater for Darlington County, South Carolina. Groundwater is also obtainable from the unconfined surficial aquifer that typically extends from land surface to a depth of approximately 30 to 50 feet below land surface. Groundwater in the surficial aquifer is generally unconfined and recharged primarily from precipitation, losing streams and rivers, and up-flow from underlying aquifers. The surficial aquifer is underlain in the region by fine- to coarse-grained sands with discontinuous layers of sandy clays, kaolins, and gravel. The base of the surficial aquifer typically displays an increase in clay and kaolin and is considered to be the upper confining unit of the Middendorf aquifer. The weathered nature of the sediments in addition to similar parent material makes the exact transition between the surficial aquifer and underlying aquifers very difficult to identify.

The Middendorf aquifer overlies crystalline bedrock and extends from the Fall Line in the upper coastal plain to the Atlantic coast. Sediment within the aquifer is described as sand to gravelly sand with varying degrees of induration. Transmissivity values in the Middendorf aquifer are relatively high with individual supply wells obtaining groundwater from the aquifer producing yields of up to 2,000 gallons per minute. Groundwater in the Middendorf aquifer is under artesian conditions with primary recharge along the outcrop of the aquifer along the Fall Line and minor recharge controlled by differences in hydraulic head with neighboring aquifers. The Middendorf aquifer has reportedly experienced a potentiometric head loss of greater than 195 feet since "predevelopment" in 1927 to current levels. The primary reason for this substantial head loss has been attributed to an increase in groundwater demand in the region (Catlin 2008).

## 2.4 Site Geology/Hydrogeology

### 2.4.1 Site Geology

Based on HDR's review of soil boring and monitoring well installation logs provided by Duke Energy for previous work completed on site as well as our observations made during the current subsurface investigation, stratigraphy in the vicinity of the ash basin consists of the following material types: fill, ash, alluvium, Coastal Plain sediments, and bedrock. In general, fill was restricted to borings advanced through the ash basin dam while ash is restricted to the confines of the basin. Alluvium was present beneath ash in several borings advanced into the historic drainage feature that was dammed to create the ash basin. Coastal Plain sediments consisting predominantly of sand with some silt and clay were encountered across the site. Bedrock was reportedly encountered at 398 feet below ground surface during installation of supply Well D in December 2004. Well D is located adjacent to the Unit 2 facility, approximately 4,900 feet south of the ash basin. The general stratigraphic units, in sequence from the ground surface down to boring termination, are defined as follows:

- **Fill** – Fill material generally consisted of re-worked sand and silt that were borrowed from one area of the site and re-distributed to other areas. Based on a 1956 Earth Dam and Spillway drawing provided by Duke Energy, fill was placed around a 12-foot-wide compacted impervious core during construction of the ash basin embankment.
- **Ash** – Ash is present within the ash basin and 1960 Fill Area. Ash has been characterized in the field as gray to dark gray fine- to coarse-grained material.
- **Alluvium** – Alluvium is unconsolidated soil and sediment that has been eroded and re-deposited by streams and rivers. Alluvium may consist of a variety of materials ranging from silts and clays to sands and gravels. Alluvium was present beneath ash in several borings advanced into the historic drainage feature that was dammed to create the ash basin.
- **Coastal Plain Sediments** – Coastal Plain sediments representing fluvial or upper delta-plain depositional environments are found across the site. Based on boring logs reviewed, sediments were characterized as yellow, reddish yellow, pink, pale brown, or brown coarse- to fine-grained sand with gray to white to pink clay lenses and extend to an average depth of greater than 300 feet below ground surface (bgs).
- **Bedrock** – Bedrock was encountered in several historic well borings in the vicinity of the Unit 2 facility. Bedrock was described as "greenish rock" and presumed to represent glauconitic basement rock of the Piedmont. Bedrock was not encountered during the current conceptual closure assessment activities.

Based on the presence of alluvium and unconsolidated sediments beneath the ash basin embankment, Duke Energy will conduct liquefaction analyses during the next phase of work to determine susceptibility to differential settlement resulting from seismic events and determine engineering remedies to mitigate for potential differential settlement.

Boring logs and laboratory reports providing detailed geologic information are provided in the Data Report (HDR 2014). Based on the results of exploration activities as well as review of historical borings, well data, and drawings provided by Duke Energy, HDR developed four

cross-sections (A-A' through D-D') to illustrate our interpretation of the hydrostratigraphy of the site. General section descriptions are:

- Section A-A' extends approximately west to east (i.e., longitudinally) through the ash basin
- Section B-B' extends north to south across the ash basin and dry stack area in the western extent of the basin
- Section C-C' extends north to south across the central part of the ash basin
- Section D-D' extends north to south across the eastern extent of the ash basin

The locations of cross-section lines are shown on **Figure 3**. Cross-sections A-A' and B-B' are shown on **Figure 4**. Cross-sections C-C' and D-D' are shown on **Figure 5**. Note that cross-sections are interpretations and that conditions between borings are estimated and/or inferred and were developed in part from historic drawings.

### 2.4.2 Site Hydrogeology

Groundwater occurrence within and around the ash basin was relatively uniform and generally follows topography across the site. Hydrogeologically, groundwater was encountered under unconfined conditions in the surficial aquifer at depths ranging from 28.44 to 44.69 feet below the top of well casings in shallow wells in the vicinity of the ash basin (excluding well MW-108S as it is located on top of the dry ash stack). The exploration program was developed to include installation of paired monitoring wells in many locations to evaluate groundwater characteristics in the upper and lower portions of the unconfined aquifer. Note that groundwater elevations between paired wells seldom varied by more than 1 foot confirming that the portion of the unconfined aquifer that was the subject of this investigation (shallower than 100 feet) is composed of relatively homogenous material with little or no significant confining layers present.

Subsequent to completion of the well installation program, groundwater elevations in the monitoring wells were measured during a comprehensive gauging event on November 17, 2014. Additional gauging and sampling events are proposed in Section 7.0 of this report to allow for evaluation of groundwater position relative to seasonal variations.

Groundwater elevations measured in shallow monitoring wells installed within the ash basin footprint ranged from 227.82 feet in well MW-110S to 235.53 feet in well MW-108S. Corresponding ground surface elevations at wells MW-110S and MW-108S are 270.17 and 283.97 feet, respectively. Groundwater elevations measured in wells located beyond the ash basin waste boundary ranged from 222.67 in well MW-112S to 236.44 in well MW-107S. Groundwater elevations measured in shallow wells installed within the 1960 Fill Area ranged from 226.30 feet in well MW-118S to 229.25 feet in well MW-117S.

Based on groundwater elevation data collected on November 17, 2014, approximately 18 feet of ash was located below the groundwater table in the vicinity of well pair MW-109S/D. Additional groundwater data collection and post-closure groundwater modeling is necessary to precisely predict the post-closure long term groundwater level in the ash and whether additional mitigation measures are necessary to protect groundwater. Groundwater elevations for monitoring wells installed during the current investigation are presented in **Table 1**. Potentiometric surface maps

for shallow and deeper wells, based on groundwater elevations obtained on November 17, 2014, are shown on **Figures 7 and 8**. Groundwater table position is shown in each of the four previously referenced cross-sections.

## 2.5 Surface Water

The Robinson Plant site is located along the western extent of Lake Robinson. The ash basin was formed via construction of a dam across an unnamed tributary to Black Creek in the mid-1970s. Modifications to the ash basin and ash basin riser barrel in the early 1980s and early 2000s are shown on Carolina Power and Light Drawing D-1777 (May 1982) and Law Engineering and Environmental Services, Stormwater Drainage Improvements, Modifications to Ash Pond (December 2002). The inlet elevation for the upstream riser barrel (Skimmer-005) is 263.87 feet. The 36-inch reinforced concrete pipe (RCP) exiting the riser barrel and embedded in the ash basin embankment enters Catch Basin No. 2, having an inlet elevation of 256.04 feet. The outlet from Catch Basin No. 2 enters new Catch Basin A with an inlet elevation of 243.5 feet. The outlet pipe (36-inch HDPE) from Catch Basin A exits into the discharge canal with an invert elevation of 234.12 feet.

Based on our review of the Site Information drawing prepared by AMEC including the 100-year flood boundary (Federal Emergency Management Agency, Flood Insurance Study, Darlington County, South Carolina, effective February 6, 2013), the ash basin is located within the 100-year flood zone. The 100-year flood level for Lake Robinson adjacent to the ash embankment is shown as 220.96 feet. The crest of the ash basin embankment is 270 feet, which is 49.04 feet higher than the flood level. In addition, the inlet elevation for Catch Basin A located at the downstream toe of the ash pond embankment is 22.54 feet higher than the 100-year flood plain elevation. The historic design drawings provided by Duke Energy (D-1777 and LAW (2002) indicate the ash pond will not flood due to stated riser barrel and catch basin inlet elevations. It appears that the AMEC Site Information drawing shows the intrusion of Lake Robinson's 100-year flood boundary into the ash basin. It is our opinion that the floodplain mapping did not consider the presence of the riser barrel and catch basin configuration, and as such, the ash basin should not be considered to lie within the 100-year floodplain of Lake Robinson. That said, the preferred ash basin closure option will evaluate and mitigate for any potential impacts resulting from the 100-year flood level (i.e., 220.96 feet).

# 3.0 Field Exploration

The field exploration program was implemented between July and November 2014 to characterize the geotechnical and environmental conditions of the ash basin and 1960 Fill Area. The subsurface investigation included completion of 22 environmental soil borings; 11 geotechnical soil borings; installation of 30 groundwater monitoring wells; and subsequent soil, ash, groundwater, and free water sample collection and testing.

Drilling was conducted by SAEDACCO under the full-time oversight of HDR personnel. Data obtained from the subsurface investigation included boring logs, monitoring well logs, and well construction records. Boring and well survey information are included in the Data Report (HDR 2014). As-built boring and well locations are shown on **Figure 3**.

Field exploration also included a natural resources survey of the site to identify wetlands and the potential for threatened/endangered species whose presence may affect closure of the ash management facilities. A summary of field exploration methods is presented in the following sections.

## 3.1 Subsurface Exploration

Exploration was conducted by various methods selected for their ability to measure and collect the required data in the field. In general, the geotechnical and environmental exploration programs were implemented independent of one another, although the data collected from those investigations is frequently cross-referenced during evaluation.

### 3.1.1 Soil Borings

The subsurface investigation consisted of the completion of 22 environmental soil borings and 11 geotechnical soil borings. Of these borings, 10 were completed within the ash basin, 3 were completed within the 1960 Fill Area ash boundary, 4 were completed through the ash basin dike, 11 were completed down- or cross-gradient of the ash management areas, and 5 were completed in background locations as shown in the table below.

| Boring Location | Geotechnical | | Environmental | |
|---|---|---|---|---|
| | Quantity | Boring IDs | Quantity | Boring IDs |
| **Ash Basin** | 4 | AP-2, AP-5, AP-9, AP-10 | 6 | AP-2, AP-5, AP-6, AP-7, AP-9, AP-10 |
| **Ash Basin Dike** | 2 | DD-1 and DD-2 | 2 | DD-1 and DD-2 |
| **Cross- or Down-Gradient of Ash Basin** | 4 | AP-1, AP-3, AP-4, AP-8 | 7 | AP-1, AP-3, AP-4, AP-8, and CB-1 through CB-3 |
| **1960 Fill Area** | 0 | NA | 3 | LOL-2 through LOL-4 |
| **Background** | 1 | AP-11 | 4 | BG-1 through BG-4 |

Note: NA = Not applicable.

In general, geotechnical soil test borings were completed via hollow stem auger (HSA), cased hole, tricone, and mud rotary drilling techniques using a Diedrich D-50 track rig. Environmental

soil borings were completed via HSA using a Diedrich D-50 track rig or via continuous coring using a Geoprobe™ Direct Push Technology (DPT) track rig.

Split-spoon (SPT) and disturbed sampling were performed using a split-spoon sampler driven 18 inches into the ground with an automatic 140-pound hammer. SPT was conducted at 5-foot intervals (3 feet between samples) for ash fill materials and the underlying in-situ soils (e.g., 4–6, 9–11, 14–16, 19–21 feet, etc.) for dual purpose environmental/geotechnical borings.

For borings advanced for geotechnical testing only, SPT was conducted at 2.5-foot intervals (1 foot between samples) to a depth of 20 feet and was then conducted at 5-foot intervals to the boring termination depth. Undisturbed Shelby tube samples were pushed with the hydraulic drill rig 24 inches into the ground to obtain samples at the desired interval. Piston sampler tubes were also taken in selected borings.

For environmental soil borings completed with the DPT rig, continuous soil cores were collected using a macro-core sampler with new polyvinyl chloride (PVC) sample liners.

After collection, the sampler was opened and recovered material was described in the field in accordance with the Unified Soil Classification System (USCS). For geotechnical borings, a selected portion of the sample was transferred into a container, sealed, and transported to the on-site storage area to await laboratory testing assignment. For environmental borings, select samples were transferred to containers provided by a third-party analytical testing laboratory (Pace Analytical Services, Inc.), stored on ice in a laboratory-provided cooler, and shipped to the laboratory under chain-of-custody protocol. Soil samples were obtained from each boring and submitted to independent laboratories for geotechnical and environmental property testing as discussed in Section 4.2.1.

Upon completion, all borings were backfilled with bentonite or grout unless a monitoring well was installed.

### 3.1.2 Monitoring Well Construction

The subsurface investigation also included installation of 30 groundwater monitoring wells. In general, wells were installed as paired “shallow” and “deep” wells with shallow wells screened across the water table surface and deep wells installed as cased wells screened at depth to evaluate vertical variations in water quality conditions. Of the 30 wells, 17 were installed within and around the ash basin, 8 were installed within and around the 1960 Fill Area, and 5 were installed in background locations up-gradient of the ash basin and 1960 Fill Area as shown in the table below.

| Well Location | Quantity | Well IDs |
|---|---|---|
| **Ash Basin** | 6 | MW-108S, MW-108D, MW-109S, MW-109D, MW-110S, MW-110D |
| **Toe of Ash Basin Dam** | 2 | MW-102D and MW-7D |
| **Cross- or Down-Gradient of Ash Basin** | 9 | MW-107S, MW-107D, MW-111S, MW-111D, MW-112S, MW-113S, MW-113D, MW-114S, MW-114D |
| **1960 Fill Area** | 4 | MW-105S, MW-105D, MW-106S, MW-106D |
| **Cross- or Down-Gradient of 1960 Fill Area** | 4 | MW-117S, MW-117D, MW-118S, MW-118D |
| **Background** | 5 | MW-101D, MW-115S, MW-115D, MW-116S, MW-116D |

In general, shallow wells (designated by an "S" qualifier) were installed as Type III wells with 2-inch-diameter Schedule 40 PVC casing and 10-foot well screens set to bracket the water table at the time of installation using HSA drilling techniques. Due to the presence of flowing sands encountered at depth, deep wells were installed using mud rotary drilling techniques. Deeper wells (designated by a "D" qualifier) were completed as cased Type III wells with a 6-inch-diameter Schedule 40 PVC outer casing generally set at least 15 feet below the bottom of the adjacent shallow well screen, and completed with a 2-inch-diameter Schedule 40 PVC casing and 5-foot well screen placed at least 10 feet below the bottom of the outer casing.

Subsequent to completion, all newly installed monitoring wells were developed to create an effective filter pack around the well screen and to remove fine particles within the well. Specific details regarding well development procedures and benchmarks were provided in the Data Report (HDR 2014).

### 3.1.3 Topographic and As-Built Well Surveys

Between July and November 2014, WSP USA Corp (WSP) completed topographic mapping of an approximate 800-acre area of the site and portions of adjacent properties via aerial and conventional ground run surveying methods. Horizontal and vertical control was tied to existing South Carolina Geodetic Survey NAD83 (2011) and NAVD88 datum. Topography was compiled at a 2-foot contour interval for areas within and adjacent to the ash basin and 1960 Fill Area and at a 4-foot interval for all other areas included in the mapping area.

Subsequent to well completion, WSP also surveyed the locations, ground elevations, and top of casing elevations of the 30 newly installed monitoring wells at an accuracy of less than 0.1 foot.

The topographic and well surveys were conducted to provide a basis for calculating ash volumes, landfill design, and groundwater position as it pertains to the conceptual closure plan proposed herein. Copies of the preliminary surveys prepared by WSP are included as Appendix A.

### 3.1.4 Water Sampling

Monitoring well sampling was performed by Pace Analytical Services, Inc. (Pace) personnel in August and November 2014. Groundwater samples were collected from 20 newly installed monitoring wells located within and near the ash basin and from 10 newly installed monitoring wells located within and near the 1960 Fill Area to assess groundwater quality. Samples were collected using low-flow sampling techniques in general accordance with USEPA Region 1 Low Stress (low flow) Purging and Sampling Procedure for the Collection of Groundwater Samples from Monitoring Wells (revised January 19, 2010).

Free water sampling was performed by Pace personnel in August 2014. One free water sample was collected from the discharge canal using a telescoping cup sampler to assess water quality down-gradient of the ash basin.

### 3.1.5 Hydraulic Conductivity Testing

Following groundwater sampling, in-situ hydraulic conductivity tests (slug tests) were performed in each of the newly installed monitoring wells. In the absence of specific SCDHEC slug testing guidance, the slug tests were performed to meet the requirements of the North Carolina

Department of Environment and Natural Resources memorandum titled Performance and Analysis of Aquifer Slug Tests and Pumping Tests Policy dated May 31, 2007. Slug testing was conducted to evaluate the horizontal hydraulic conductivity (K) of aquifer materials relative to monitoring well screen position. Hydraulic conductivity is an important parameter needed to understand groundwater movement and how it impacts closure options and design.

## 3.2 Natural Resources Surveys

On November 13, 2014, HDR biologists conducted an on-site investigation consisting of a delineation of jurisdictional waters of the United States and habitat and individual species surveys for federally protected species within an approximately 660-acre study area on property owned by Duke Energy (**Figure 7**). The purpose of the Natural Resources Survey was to evaluate whether the presence of such features/habits would potentially constrain the preferred closure option. The following sections provide a summary of HDR's methods employed during natural resources survey. Findings of the survey are presented in Section 4.3.

### 3.2.1 Data Review

HDR conducted a desktop survey of publically available data from federal and state agencies prior to engaging in field reconnaissance surveys. The following sources were reviewed as part of this analysis:

- ESRI ArcGIS online aerial imagery, streets, and basemap information
- National Hydrography Dataset (NHD), U.S. Geological Survey (USGS) (http://nhd.usgs.gov/)
- National Wetland Inventory (NWI), U.S. Fish and Wildlife Service (USFWS) (http://www.fws.gov/wetlands/)
- South Carolina List of At-Risk, Candidate, Endangered, and Threatened Species – Darlington County, USWFS (http://www.fws.gov/charleston/EndangeredSpecies_County.html )
- South Carolina Rare, Threatened and Endangered Species Inventory Quadrangle Search, South Carolina Department of Natural Resources (SCDNR) Heritage Trust Program (https://www.dnr.sc.gov/pls/heritage/species.select_quad_map?pcounty=darlington )
- Soil Survey for Darlington County, Natural Resources Conservation Service (NRCS) (http://www.nrcs.usda.gov/Internet/FSE_MANUSCRIPTS/south_carolina/SC031/0/Darlington.pdf )
- USGS Lake Robinson 24K Quadrangle (**Figure 9**)

### 3.2.2 Jurisdictional Waters of the U.S.

HDR surveyed the defined study area for jurisdictional waters of the U.S. under Section 404 of the Clean Water Act. The study area was examined according to the methodology described in the U.S. Army Corps of Engineers (USACE) 1987 Wetland Delineation Manual, USACE Post-Rapanos guidance, and the USACE Atlantic and Gulf Coastal Plain Regional Supplement. The North Carolina Division of Water Resource's Methodology for Identification of Intermittent and Perennial Streams and Their Origins (Version 4.11) was used to determine the

presence/absence of jurisdictional streams since no stream identification protocol has been established by SCDHEC. Jurisdictional waters were classified in accordance with the Classification of Wetlands and Deepwater Habitats of the United States (Cowardin et al. 1979).

### 3.2.3 Vegetative Communities

Vegetation community types were documented and categorized based on the Natural Communities of South Carolina Initial Classification and Description developed by Nelson (1986). Dominant species in the canopy, shrub/subcanopy, herbaceous, and vine strata were identified and documented to the lowest taxonomic level based in Radford et al. 1960.

### 3.2.4 Federally Protected Species

HDR obtained and reviewed a list of federally protected species for Darlington County from the USFWS website which was last updated on October 23, 2013. A summary of these species is provided on the following table.

| Common Name | Scientific Name | Federal Status | Habitat Present |
|---|---|---|---|
| | **Bird** | | |
| **Bald eagle** | *Haliaeetus leucocephalus* | BGPA | Yes |
| **Red-Cockaded woodpecker** | *Picoides borealis* | E | Yes |
| | **Fish** | | |
| **Atlantic Sturgeon** | *Acipenser oxyrinchus* | E | No |
| **Shortnose sturgeon** | *Acipenser brevirostrum* | E | No |
| | **Plant** | | |
| **Rough-leaved loosestrife** | *Lysimachia asperulaefolia* | E | No |

BGPA – Federally protected under the Bald and Golden Eagle Protection Act
E – Federally Endangered

HDR also reviewed the SCDNR Heritage Trust Program's Rare, Threatened, and Endangered Species Inventory Quadrangle Search for protected species distribution and proximity to the study area.

# 4.0 Exploration Results

The laboratory testing program was designed to obtain geotechnical and environmental data that can be used to develop an SCM. In turn, the SCM will be used to support the preferred ash pond closure option.

## 4.1 Geotechnical Testing

Geotechnical laboratory determination of soil index properties included particle size analysis by #200 wash only or #200 wash with hydrometer analysis, Atterberg limit determination, and specific gravity determination. Testing was performed on representative soil and ash samples. Material for testing was obtained from either split-spoon samples, relatively undisturbed Shelby tube samples, or bulk samples obtained at the surface. Additional geotechnical laboratory testing included soil strength determination such as consolidated undrained with pore pressure measurements (CU) testing. Additionally, the hydraulic conductivity of selected samples was also determined. All testing was performed in accordance with the most recently updated American Society for Testing Materials (ASTM) testing standards.

The subsurface exploration has indicated that the majority of on-site soil consists of unconsolidated, loose to medium dense sand with varying degrees of silt and/or clay. Such soils, especially when saturated, may liquefy during a seismic event. Laboratory testing revealed that some of these soils are non-plastic or have a plasticity index < 7, which indicates these soils are susceptible to liquefaction. Since the sandy soils were observed to have varying relative densities at depths within the subsurface horizon, it is reasonable to expect that liquefaction of looser more saturated sand layers could lead to differential settlement of any structures founded above them, such as embankments, liners, and/or caps. Further analyses and modeling will be required to further identify the liquefaction potential of subsurface soils and to develop design criteria for embankments, and impoundment liners, and/or caps.

A summary of the geotechnical laboratory testing program is presented in the table below.

| Boring | Depth of Boring | Depth of Fill | Depth of Ash | Depth of Unconsolidated Sediments | No. of Soil Samples[2] Collected | No. of Disturbed Soil Samples Tested | No. of Undisturbed Soil Samples Tested |
|---|---|---|---|---|---|---|---|
| **AP-1** | 50.0 | - | - | 50 | D=12 | 1 | 0 |
| **AP-2** | 100.0 | - | 56 | 44 | D=8: U=2 | 2 | 0 |
| **AP-3** | 50.0 | - | - | 50 | D=12 | 1 | 0 |
| **AP-4** | 50.0 | - | - | 50 | D=12 | 4 | 0 |
| **AP-5** | 88.8 | - | 59.5 | 29.3 | D=6; U=1 | 2 | 0 |
| **AP-8** | 50.0 | - | - | 50 | D=12 | 1 | 0 |
| **AP-9** | 50.0 | - | 35.5 | 14.5 | D=9 | 1 | 0 |
| **AP-10** | 50.0 | - | 16.5 | 33.5 | D=4; U=1 | 0 | 3 |
| **AP-11[1]** | 50.0 | - | - | 50 | D=12; U=2 | 2 | 1 |
| **DD-1** | 65.0 | 22.5 | - | 42.5 | D=15 | 2 | 0 |
| **DD-2** | 71.5 | 41 | - | 30.5 | D=13; U=4 | 2 | 2 |

Notes:
1. Includes Boring AP-11A that was advanced at same location to collect undisturbed samples
2. 2. D = Disturbed Samples
3. 3. U = Undisturbed Samples

The data obtained during implementation of the geotechnical exploration program will be used to support the preferred ash basin closure option as feasibility of the option is further refined. Laboratory results of geotechnical testing are summarized in **Tables 2A and 2B**.

## 4.2 Environmental Testing

Environmental laboratory testing was performed on soil, ash, ash pore water, groundwater, and free water samples collected from borings, monitoring wells, and the ash basin discharge canal. Samples were analyzed by Pace or their subcontract laboratories in accordance with United States Environmental Protection Agency (USEPA) methods or other applicable standards.

### 4.2.1 Soil and Ash

A total of 53 soil and ash samples were collected from borings completed within the ash basin, outside of the ash basin, in the 1960 Fill Area, and in background locations. Of the 53 samples, 12 were collected in ash within the ash basin and 4 were collected in ash within the 1960 Fill Area. The remaining samples were collected in soil either beneath ash or outside of ash management areas as presented in the table below.

| Soil Boring Location | Soil Boring ID | Type and Quantity of Analyses | | |
|---|---|---|---|---|
| | | Soil | Ash | Ash - SPLP |
| **Within Ash Basin** | AP-2 | -- | 2 | 2 |
| | AP-5 | -- | 2 | 2 |
| | AP-6 | 1 | 2 | 1 |
| | AP-7 | 1 | 2 | 2 |
| | AP-9 | 1 | 2 | -- |
| | AP-10 | 1 | 2 | 1 |
| **Background Ash Basin** | BG-1 | 4 | -- | -- |
| | BG-2 | 3 | -- | -- |
| | BG-3 | 4 | -- | -- |
| **Cross-gradient of Ash Basin** | AP-1 | 1 | -- | -- |
| | AP-3 | 1 | -- | -- |
| | AP-4 | 1 | -- | -- |
| | AP-8 | 1 | -- | -- |
| **Down-gradient of Ash Basin** | DD-1 | 3 | -- | -- |
| | DD-2 | 3 | -- | -- |
| | CB-1 | 2 | -- | -- |
| | CB-2 | 2 | -- | -- |
| | CB-3 | 2 | -- | -- |
| **Within 1960 Fill Area** | LOL-2 | 1 | 1 | 1 |
| | LOL-3 | 1 | 2 | 1 |
| | LOL-4 | 1 | 1 | 1 |
| **Background1960 Fill Area** | BG-4 | 3 | -- | -- |

Note:
1. SPLP = Synthetic Precipitation Leaching Procedure

The 53 samples were submitted to Pace for analysis of total antimony, arsenic, barium, beryllium, boron, cadmium, chromium, cobalt, copper, iron, lead, manganese, molybdenum, nickel, selenium, thallium, and zinc using EPA Method 6010; chloride using EPA Method 9056; mercury using EPA Method 7471; and pH using EPA Method 9045. Eleven ash samples were

also analyzed for leaching potential of inorganic constituents using the Synthetic Precipitation Leaching Procedure (SPLP) by USEPA Method 6020/1312.

Ash and soil samples collected from within the ash basin were also analyzed for cesium-137 using Method DOE HASL 300, 4.5.2.3/Ga-01-R, and cobalt-60 using Method DOE HASL 300, 4.5.2.3/Ga-01-R, due to the 1998 approved discharge of low-level radioactive boiler cleaning wastewater to the ash basin. This disposal involved boiler chemical metal cleaning wastes that were contaminated at very low levels with Cobalt-60 (CP&L 1998).

The analytical results of the total concentration analyses were compared to Maximum Contaminant Level-based (MCL-based) USEPA Protection of Groundwater Soil Screening Levels (SSLs) and USEPA Industrial SSLs. The site is used for industrial purposes and is not anticipated to be rezoned to residential. Constituents that exceeded the USEPA Protection of Groundwater SSLs in the ash samples collected from within the ash basin and the 1960 Fill Area included antimony, arsenic, barium, beryllium, cadmium, copper, lead, mercury, and selenium. Arsenic was also reported above the USEPA Industrial SSL in the ash samples collected from within the ash basin and the 1960 Fill Area. Constituents that exceeded USEPA Protection of Groundwater SSLs in the soil samples include arsenic and selenium. Arsenic also exceeded the EPA Industrial SSL in one soil sample. Radiological parameters were not detected above the laboratory method detection limit (10.0 pCi/L) in ash or soil samples collected within the ash basin. Laboratory results of soil and ash samples are presented in **Tables 3A, 3B, 3C, and 3D**.

Laboratory results of SPLP analyses were compared to the SCDHEC Primary and Secondary MCLs for drinking water last amended on August 28, 2009. Arsenic was detected at concentrations greater than the Primary and Secondary MCLs in ash samples collected from within the ash basin. Iron and manganese were measured at concentrations greater than the Primary and Secondary MCLs in ash samples collected from within the 1960 Fill Area. Leaching results of select samples of ash are presented in **Table 4**.

The results of environmental soil and ash analyses will be evaluated to derive a list of site-specific constituents of concern (CoC) and to evaluate the leaching potential of those CoC from ash into underlying soils and/or groundwater.

### 4.2.2 Groundwater

Between August and November 2014, groundwater samples were collected from 20 newly installed monitoring wells located within and near the ash basin and from 10 newly installed monitoring wells located within and near the 1960 Fill Area to assess groundwater water quality.

Samples were collected for both total and dissolved concentration analyses. The samples collected for dissolved concentration analyses were filtered by Pace in a laboratory controlled environment. The samples were submitted to Pace for analysis as follows:

- Antimony, arsenic, barium, beryllium, boron, cadmium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese, molybdenum, nickel, potassium, selenium, sodium, and zinc using USEPA Method 200.7 (total and dissolved concentrations)

- Mercury using USEPA Method 245.1 (total and dissolved concentrations)
- Thallium using USEPA Method 200.8 (total and dissolved concentrations)
- Alkalinity using SM 2320B
- Bromide, chloride, and sulfate using USEPA Method 300.0
- Ferrous iron using SM 3500-Fe B
- Methane using RSK 175
- Nitrate as nitrogen using USEPA Method 353.2
- Sulfide using SM 4500-S2D
- Total dissolved solids using SM 2540C

Ash pore water and groundwater samples collected from within the ash basin were also analyzed for cesium-137 using Method DOE HASL 300, 4.5.2.3/Ga-01-R, and cobalt-60 using Method DOE HASL 300, 4.5.2.3/Ga-01-R, to evaluate potential impacts from the 1998 approved discharge of low-level radioactive boiler cleaning wastewater to the ash basin.

Constituents detected at concentrations that meet or exceed the Primary and Secondary MCLs in the ash pore water samples include arsenic (samples MW-108S and MW-109S), iron (sample MW-108S), manganese (samples MW-108S and MW-109S), and pH (sample MW-108S). Constituents detected at concentrations that meet or exceed the Primary and Secondary MCLs in the groundwater samples include arsenic (sample MW-7), iron (11 samples), manganese (17 samples), and pH (22 samples). Radiological parameters were not detected above the laboratory reporting limit (10.0 pCi/L) in wells screened within or below ash in the ash basin. Laboratory results of groundwater samples are summarized in **Table 5A** (total inorganics), **Table 5B** (major anions and cations), **Table 5C** (dissolved inorganics), and **Table 5D** (radiological isotopes).

### 4.2.3 Free Water

One free water sample was collected by Pace personnel in August 2014 from the discharge canal to assess water quality down-gradient from the ash basin. The free water sample was analyzed for total and dissolved concentrations of the same suite of constituents/parameters as the groundwater samples with the exception of radiological parameters. Total and dissolved concentrations of barium, iron, and manganese were detected above their respective laboratory reporting limits in the free water sample. No other constituents were detected above their reporting limits. Laboratory results of the free water sample are summarized in **Table 6**.

The results of water analyses will be evaluated to derive a list of site-specific CoC, to evaluate whether leaching of those CoC from ash into groundwater has occurred, to evaluate the position of groundwater relative to ash, and to evaluate the potential for off-site migration of CoC at concentrations that exceed applicable water standards in support of the of the preferred ash basin closure option as feasibility of the option is further refined.

## 4.3 Natural Resources Survey

The following sections summarize the findings of the Natural Resources Survey conducted at the Robinson Plant site on November 13, 2014, as described in Section 3.2 of this report.

### 4.3.1 Jurisdictional Waters of the U.S.

Based on the Classification System of Wetlands and Deepwater Habitats of the United States (Cowardin et al. 1979), identified waters can be described as: deep water Lacustrine; Limnetic; Unconsolidated Bottom; Permanently Flooded; Diked/Impounded (L1UBHh) with adjacent fringe Palustrine; Emergent; Seasonally Flooded; Diked/Impounded (PEMCh) and Palustrine; Scrub-Shrub; Broad-Leaved Deciduous; Seasonally Flooded; and Diked/Impounded (PSS1Ch). No jurisdictional streams were located within the study area.

Jurisdictional waters identified are shown on **Figure 10**. USACE Wetland Determination Data forms are provided in **Appendix B**. A summary of the delineated feature is provided in the table below.

| Site Number or Name | Latitude | Longitude | Cowardin Classification | Estimated Amount of Aquatic Resources in Study Area | Class of Aquatic Resources |
|---|---|---|---|---|---|
| **Open Water** | 34.41778 | -80.15945 | L1UBHh | 2.81 | Section 10 – Non-Tidal |

### 4.3.2 Vegetative Communities

**Disturbed/Maintained**

Maintained/disturbed areas are scattered throughout the study area and include land north of Icy Street, maintained right-of-ways (ROW), and the 1960 Fill Area. These areas are dominated by immature pines (*Pinus* sp.), asters (*Aster* sp.), black cherry (*Prunus serotina*), blackberry (*Rubus* sp.), big bluestem (*Andropogon gerardii*), Chinese privet (*Ligustrum sinense*), dogfennel (*Eupatorium capillifolium*), fescue (*Fescue* sp.), goldenrods (*Solidago* sp.), Japanese honeysuckle (*Lonicera japonica*), Johnson grass (*Sorghum halepense*), sumac (*Rhus* sp.), and other early successional species.

**Pine-Scrub Oak Sandhill**

The pine-scrub oak sandhills are located primarily in the western portion of the study area. The canopy is dominated by longleaf pine (*Pinus palustris*) and understory species consist of a high percentage of scrub oaks including bluejack oak (*Quercus incana*), blackjack oak (*Quercus marilandica*), and turkey oak (*Quercus laevis*). Additional understory and shrub species include black cherry, dwarf huckleberry (*Gaylussacia dumosa*), flowering dogwood (*Cornus florida*), highbush blueberry (*Vaccinium stamineum*), mockernut hickory (*Carya tomentosa*), sassafras (*Sassafras albidum*), and sweetgum (*Liquidambar styraciflua*). Herbaceous species included bluestem (*Andropogon* sp.) and bracken fern (*Pteridium aquilinum*).

**Mixed Pine/Hardwood Forest**

The community located north of the backwater cove below the ash basin does not fall into a distinct natural community type as described by Nelson. The canopy is dominated by loblolly pine (*Pinus taeda*), hickories (*Carya* sp.), and sweetgum. Understory and shrub species consist of American holly (*Ilex opaca*), black cherry, flowering dogwood, highbush blueberry, and wax myrtle. Vine species include Japanese honeysuckle, poison ivy (*Rhus radicans*), and yellow jasmine (*Gelsemium sempervirens*).

### 4.3.3 Federally Protected Species

The Lake Robinson Quadrangle search revealed several known occurrences of red-cockaded woodpecker located in the Sandhills State Forest approximately 5 miles north of the study area. The following is a summary of biological conclusions for species that are protected under provisions of Section 7 and Section 9 of the Endangered Species Act of 1973 and the Bald and Golden Eagle Protection Act (BGPA).

**Bald Eagle (*Haliaeetus leucocephalus*)**

The study area is located near open water (Lake Robinson). No known occurrences of bald eagle have been documented nearby. No individuals or nests were noticed within the study area during the on-site investigation. It is recommended that a follow-up survey be conducted should any future on-site activities require Section 7 consultation with United States Fish and Wildlife Service (USFWS).

**Red-Cockaded Woodpecker (*Picoides borealis*)**

Minimal areas of suitable habitat for the Red-Cockaded Woodpecker exist within the study area. No mature nesting trees were noticed on site. There are a few stands of estimated 20–30 year (estimate) longleaf pines within the study area suitable for foraging; however, the pine stands are not fire maintained and have a thick understory consisting of scrub oaks and other hardwoods which are a limiting factor. Potential foraging habitat for the Red-Cockaded Woodpecker would be restricted to a few areas with mature pines, little or no understory, and abundant herbaceous ground cover within the study area. No individuals or cavity trees were noticed within the study area during the onsite-investigation. It is recommended that a follow-up survey be conducted should any future onsite activities require Section 7 consultation with USFWS.

**Atlantic Sturgeon (*Acipenser oxyrinchus*)**

No suitable habitats are located within the study area. No known occurrences or historic populations of Atlantic Sturgeon have been recorded in Lake Robinson.

**Shortnose Sturgeon (*Acipenser brevirostrum*)**

No suitable habitats are located within the study area. No know occurrences or historic populations of Shortnose Sturgeon have been recording in Lake Robinson.

**Rough-Leaved Loosestrife (*Lysimachia asperulaefolia*)**

The study area does not have suitable ecotone habitat between existing longleaf pine stands and wetter areas that may include pocosins, wet pine savannas, or streamhead seeps. No known occurrences have been documented nearby and this species in now considered to extirpated in Darlington County (NatureServe 2014).

### 4.3.4 Natural Resources Survey Conclusions

Based on the data reviewed and observations made during the natural resources survey of the site on November 13, 2014, HDR did not identify Jurisdictional Waters of the U.S., wetlands, vegetated communities, or threatened and endangered species in parts of the site that would likely be impacted by closure of the ash basin or movement of ash from the 1960 Fill Area.

# 5.0 Summary of Completed and On-Going Work

Between July and November 2014, Duke Energy has completed a field exploration program consisting of the following:

- Completion of 22 environmental soil borings and 11 geotechnical soil borings
- Installation, development, and sampling of 30 shallow and deep groundwater monitoring wells
- Hydraulic conductivity testing of 29 newly installed monitoring wells
- Laboratory testing of 18 disturbed and 6 undisturbed soil and ash samples for geotechnical parameters
- Laboratory analysis of 53 soil and ash samples, 30 groundwater samples, and 1 free water sample for potential CoC and natural attenuation indicator parameters

Evaluation of these data is on-going in support of a permanent ash basin closure option that is protective of human health and the environment and acceptable to SCDHEC Bureau of Water per their guidance Proper Closeout of Wastewater Treatment Facilities, Regulation 61-82, dated April 11, 1980. Given the results obtained from the geotechnical and environmental exploration and testing programs thus far, Duke Energy intends to evaluate three potential permanent ash basin closure options (described in more detail in Section 6.0):

- **Hybrid Cap-in-Place** whereby coal ash residue from the 1960 Fill Area would be excavated and placed into the ash basin, ash immediately behind the ash basin embankment would be moved farther west within the basin to allow breaching or removal of the dam, and consolidated ash within the basin would be capped with an engineered cover system. Potential areas of saturated ash within the basin post-closure (based on SCM modeling) would be reduced or eliminated using appropriate engineering measures (e.g., removal of ash from saturated areas, fixing ash in place via soil mixing and/or injection of stabilizing materials, installation of infiltration cut-off walls on the upstream side of the ash basin, etc.) to prevent or minimize leaching of coal ash constituents to down-gradient areas.

- **On-Site Landfill** whereby coal ash residue from the 1960 Fill Area and ash basin would be excavated and moved to a lined landfill designed to contain coal ash residue. While not thoroughly investigated at this time, an on-site landfill could potentially be located on the northwest side of the Darlington County Plant.

- **Off-Site Landfill** whereby coal ash residue from the 1960 Fill Area and ash basin would be excavated and hauled to a lined landfill designed and permitted to receive coal ash residue. This could either be an existing lined landfill with capacity and ability to accept the coal ash residue or a newly constructed lined landfill permitted to accept coal ash residue.

Based on preliminary data analyses, it appears that up to 18 feet of ash is saturated in the deepest portion of the ash basin (between the transmission line right-of-way and the ash basin embankment). Additional groundwater data collection and post-closure groundwater modeling is necessary to precisely predict the post-closure long-term groundwater level in the ash. While the saturated depth of ash diminishes moving away from this area, it is uncertain at this time if the Hybrid Cap-in-Place closure method will reduce the amount of saturated ash in the basin to a point where this option becomes viable. Further evaluation of data is on-going in support of the preferred closure option. To that end, Duke Energy intends to perform the following work:

- Conduct further analyses of the foundation soils at the ash basin and embankments, for the Hybrid Cap-in-Place option, to determine susceptibility to liquefaction of in-situ soils during seismic events. Such liquefaction could result in differential settlement of a liner or cap and/or induced embankment failure. Analyses may consist of, but would not be limited to, laboratory cyclic triaxial testing of remolded soil samples conducted in conjunction with additional in-situ soil testing. These studies and follow-up finite element analysis will help determine engineering remedies for mitigating potential liquefaction induced differential settlements. The analyses will also be used to develop design criteria for static and post-seismic embankment stability.

- Evaluate potential impacts to the ash basin embankment and ash basin resulting from a postulated 100-year flood event; and determine engineering remedies to mitigate for potential impacts

- Evaluate laboratory results from in-basin, near-basin, and background sample locations to determine site-specific coal ash residue CoC and eliminate naturally occurring compounds from future consideration as CoC

- Develop calculations of ash sample SPLP results to evaluate the potential for leaching of coal ash residue CoC from ash into the groundwater

- Conduct three additional rounds of groundwater sampling between January and August 2015 to evaluate potential seasonal variations in groundwater quality data and groundwater surface elevations

- Complete groundwater fate and transport modeling (i.e., SCM) of site-specific coal ash residue CoC to evaluate mobility and concentration gradients over time, and evaluate post-closure groundwater elevations in the ash basin as it relates to potential additional groundwater protection measures

The above work activities will be used to evaluate Hybrid Cap-in-Place as a permanent ash basin closure option. If Hybrid Cap-in-Place is not a suitable closure option, the On-Site and Off-Site Landfill closure options will be further investigated to determine which of these options is preferred.

Duke Energy intends to submit a detailed Supplemental Conceptual Closure Plan to SCDHEC Bureau of Water by November 20, 2015. This supplement will provide the analysis for and recommend a preferred permanent closure option for the Robinson Plant ash basin.

# 6.0 Potential Ash Basin Closure Options

As described in Section 5.0, Duke Energy intends to evaluate three permanent ash basin closure options for the ash management areas (i.e., ash basin and 1960 Fill Area) at the Robinson Plant site:

- Hybrid Cap-in-Place
- On-Site Landfill
- Off-Site Landfill

Physical and environmental closure approaches for each closure option are discussed in the sections below. Note that the scope of long-term groundwater quality management will be dependent on the results of additional groundwater sampling and subsequent groundwater modeling. Groundwater protection measures will be addressed in the forthcoming Supplemental Conceptual Closure Plan.

## 6.1 Ash and Earthwork Quantities

The quantities of ash and impacted soil to be consolidated within the ash basin and the quantity of clean cover soil required for cap construction were estimated for the proposed Hybrid Cap-in-Place ash basin closure option. The methods used to calculate the ash and earthwork quantities associated with the various components of the ash basin closure follow. A summary of the calculated quantities is provided in **Table 7**. Unless specifically noted, the quantities are in-place (i.e., bank measure) quantities that do not include swell or shrinkage factors.

### 6.1.1 1960 Fill Area

Although closure of the 1960 Fill Area will be regulated by the SCDHEC Bureau of Solid Waste, and not by the Bureau of Water, it is assumed that ash removal from the 1960 Fill Area will be handled in conjunction with closure of the ash basin.

The quantity of ash currently within the 1960 Fill Area was previously estimated at approximately 275,800 cy (AMEC 2014). The same reference estimated that approximately 19,600 cy of cover soil had been placed over the ash in the 1960 Fill Area. Due to the relatively thin layer of cover present (typically less than 1 foot) and the length of time the cover has been in-place (since the 1970s), it is assumed that removal and reuse of the cover soil without intermixing with ash will be impractical. In addition, it is assumed that an average of 2 feet of soil has been impacted by the ash beneath the entire 25.0 acre 1960 Fill Area footprint, which is equivalent to 80,800 cy of soil. As a result, the estimated total volume of ash and soil to be removed from the 1960 Fill Area and consolidated within the ash basin is 376,200 cy. Drawing C-01 shows the estimated post-ash excavation grades within the 1960 Fill Area.

### 6.1.2 Ash Basin Area

The total quantity of ash within the ash basin was estimated by digitizing pre-basin contours obtained from a topographic map of the site (Carolina Power & Light Company, 1981) into CAD format and comparing that surface to a surface generated from a recently developed

topographic map of the Robinson site (WSP Transportation and Infrastructure 2014). The quantity of ash within the ash basin area is estimated to be between 3.0 and 3.5 million cy which includes the existing Dry Ash Storage Area located west of the transmission lines that extend over the basin. This volume should be used with caution, however, since it is possible that the ash basin area may have been altered (e.g., by borrow operations to build the ash basin dam or other earthen structures) between the date of the pre-basin topography and when ash began being placed within the basin. Borings conducted within the ash basin as part of the closure investigation appear to support the premise that the grades within the basin were reworked prior to ash disposal since ash was encountered below the aforementioned pre-basin contours. The accuracy of the pre-basin topography is also questionable since information on the original source of the topography is not available and the vertical and horizontal datum is not known. Furthermore, the topographic contours outside of the basin limits deviate between the two surveys. The limits of ash were also estimated based on topographic features and aerial photographs but cannot be determined with a high degree of confidence without field verification. Discrepancies within the limits of ash could also introduce inaccuracy with respect to the total calculated ash volume.

### 6.1.3 Ash Basin Embankment

The ash basin embankment, located on the east side of the ash basin, was constructed out of general fill materials surrounding a 12-foot-wide compacted impervious core. If the main dam is lowered or removed as part of the overall ash basin closure process, the earthen material could likely be reused as a source of cover soil. The quantity of soil within the dam was estimated by comparing the digitized pre-basin contours to the recent topographic map of the Robinson site as previously described. The upstream profile of the dam, currently overlaid with ash, was estimated based on the original design sections (EBASCO Services Incorporated 1958). The estimated quantity of soil comprising the main dam is 309,400 cy.

## 6.2 Hybrid Cap-in-Place Closure Option

Duke Energy has performed a preliminary evaluation of a Hybrid Cap-in-Place ash basin closure option for the ash basin and 1960 Fill Area at the Robinson site. The Hybrid Cap-in-Place closure option would consist of the following:

- Consolidate ash and impacted soils from the 1960 Fill Area into the existing ash basin to reduce the closure footprint
- Move ash and impacted soils from immediately behind the ash basin embankment to locations farther west within the basin to allow breaching or removal of the main dam
- Cap-in-Place consolidated portions of ash and impacted soils with an engineered cover system (soil-geosynthetic) designed to isolate and stabilize the ash while providing a physical barrier to the environment
- Re-use embankment soils for closure construction
- Decommission the ash basin and dam embankment from the SCDHEC Dams and Reservoirs Safety Program jurisdiction
- Evaluate monitored natural attenuation (MNA) for environmental closure provided environmental investigation results facilitate MNA as a remedy

- Maintain the current NPDES outfall location for stormwater discharge

Under this strategy, ash and impacted soil from the 1960 Fill Area would be re-located to the footprint of the existing ash basin and closed in-place with an engineered cap system to reduce infiltration through the ash and underlying materials thereby limiting potential for future migration of CoC. Closure would require re-shaping of the basin area to shed stormwater and route to the existing stormwater outfall.

### 6.2.1 Physical Closure

The closure approach would consider the SCDHEC Regulation 61-82 for Proper Closeout of Wastewater Treatment Facilities, the forthcoming USEPA CCR Rule, and established municipal solid waste landfill closure practices for engineered cover systems.

The Hybrid Cap-in-Place ash basin closure option has the benefits of reducing the closure footprint by approximately 30.5 acres and provides the opportunity to beneficially reuse the soil material in the main dam for engineered cover system construction. The Hybrid Cap-in-Place closure option would require approximately 162,100 cy of soil to provide an 18-inch thick soil cover as part of an engineered cover system. The amount of soil material in the main dam is more than sufficient for this purpose and excess soil could be used to construct stormwater berms and terraces required to promote surface runoff and/or to regrade the excavated 1960 Fill Area. As a result, the engineered cover system would be designed to effectively eliminate the vertical percolation of rainwater into the ash basin.

For the Hybrid Cap-in-Place closure option, approximately 1,128,400 cy of material would be placed into the ash basin including ash and impacted soils from the 1960 Fill Area, ash and impacted soils removed from the upstream face of the ash basin embankment (to allow dam embankment decommissioning), and cover soil from the embankment. This estimated volume assumes compacted ash placed within the basin has a shrinkage factor of approximately 20 percent (based on HDR's experience with coal ash and assuming a minimum dry density of 95 percent of the standard Proctor maximum dry density [ASTM D698]). A shrinkage factor of 12 percent was assumed for impacted soils compacted to a minimum dry density of 95 percent of the standard Proctor maximum dry density. A more detailed breakdown of these quantities is provided in **Table 8**.

The effectiveness of the physical closure would be dependent on the ability of the engineered cover system to lower the groundwater potentiometric surface within the ash basin such that it is below the ash. As shown on the cross sections (**Figure 5 and Figure 6**), the potentiometric surface measured during the field exploration extends up to 18 feet into the ash. If the results of groundwater modeling indicate the potentiometric surface will not be lowered sufficiently within a reasonable length of time, then the effectiveness of the physical closure will be reduced. Continued contact of groundwater with ash could result in a continuing source of release of CoCs into the environment since there would not be a physical barrier to the downgradient flow of impacted groundwater.

**Conceptual Closure Geometry**

The conceptual closure grades based on the preliminary Hybrid Cap-in-Place design are shown on Drawing C-02 (Appendix C).

As depicted in Drawing C-02, the ash basin will be divided into a West Dry Ash Storage Area and East Dry Ash Storage Area for placement of material from the 1960 Fill Area and material removed from the ash basin during closure construction (i.e., during perimeter channel construction and removal of ash immediately upstream from the main dam). This division is required to avoid interfering with the transmission lines that cross near the center of the ash basin.

**Proposed Engineered Cover System**

An engineered cover system is proposed as a means of limiting the infiltration of stormwater into the ash and impacted soils after consolidation of materials occurs at the site.

The proposed engineered cover system consists of (from bottom to top): a prepared basegrade comprised of compacted ash and/or impacted soil, a 40-mil textured linear low density polyethylene (LLDPE) geomembrane liner, a geocomposite drainage layer (GDL) consisting of a polyethylene geonet sandwiched between two layers of non-woven geotextile, 18 inches of cover soil (not impacted by ash), and 6 inches of topsoil capable of supporting vegetative growth. This basic design has been used successfully for various closure projects involving coal ash and municipal solid waste and has performed well for many years.

A textured LLDPE geomembrane liner is recommended over a high-density polyethylene liner (HDPE) due to its superior ability to accommodate strain that may result due to differential settlement that may occur due to variable ash and foundation soil properties. The geomembrane should be textured on both sides for veneer stability considerations on the ash basin sideslopes and for safety reasons during construction. The geomembrane provides a virtually impermeable barrier to the vertical percolation of rainwater through the engineered cover system into the ash and impacted soils. The LLDPE geomembrane provides superior performance over a compacted clay liner since it is subject to natural variations in hydraulic conductivity typical of clay deposits and is not subject to cracking over time due to differential settlement or root penetration. A compacted clay liner would require a borrow source classification study to identify a suitable clay source and extensive Construction Quality Assurance (CQA) and Construction Quality Control (CQC) procedures to achieve a high degree of confidence that the project specification requirements are met.

### 6.2.2 Environmental Closure

The environmental closure is concerned with the short- and long-term soil, groundwater, and surface water quality of the ash management areas. Environmental closure may take one of several pathways depending on the nature, extent, and characteristics of the CoC. For the Hybrid Cap-in-Place closure option, ash and impacted soil beneath ash would largely be left in place. Therefore, the results of leaching analyses and groundwater modeling are critical to understanding whether leaving these materials in place would impact groundwater. To date, CoC have not been established for the ash basin or 1960 Fill Areas, and thus, the preferred

environmental closure option is uncertain. Leachability calculations and groundwater modeling will be conducted and included in the Supplemental Conceptual Closure Plan.

## 6.3 On-Site Landfill Ash Basin Closure Option

Under this option, ash and impacted soil from the ash basin and the 1960 Fill Area would be relocated to the on-site lined ash landfill and closed with an engineered cap system to reduce infiltration through the ash and underlying materials, thereby limiting potential for future migration of CoC. Regrading of the ash basin and 1960 Fill Area would be required after ash and impacted soil removal to ensure that positive drainage is maintained to eliminate ponding and to ensure the final surface can be maintained without excessive erosion. Soil from the decommissioned dam embankment could be used for final grading. Topsoil would also be placed over all regraded areas to encourage the growth of vegetation. Fast-growing vegetative cover consisting of native grasses would initially be established to stabilize the excavated and regraded areas against erosion. Eventually, trees and/or shrubs would be planted or allowed to naturally populate these areas to reduce maintenance requirements.

A potential location for a lined on-site ash landfill for the disposal of ash and impacted soils from the ash basin and the 1960 Fill Area is northwest of the basin as shown on **Drawing G-01**. The natural resource surveys described in Section 3.2 indicate that this area would be suitable for development as a landfill from an ecological standpoint. The suitability of this area from a geotechnical and hydrogeological perspective, however, will need to be confirmed through a subsurface exploration and geotechnical testing program. The on-site landfill ash basin closure option would consist of the following:

- Construct a lined ash landfill with leachate collection system meeting the minimum bottom liner and final cover requirements for a SCDHEC Class 3 landfill within the area shown on **Drawing G-01**
- Consolidate ash and impacted soils from the ash basin and 1960 Fill Area into the on-site landfill
- Construct an engineered cover system (soil-geosynthetic) over the landfill
- Re-use embankment soils from the ash basin dam for engineered cover system construction, if feasible
- Establish a groundwater detection monitoring program for the ash landfill
- Decommission the ash basin and dam embankment from the SCDHEC Dams and Reservoirs Safety Program jurisdiction
- Establish vegetation within the post-closure ash basin area and 1960 Fill Area
- Evaluate monitored natural attenuation (MNA) for environmental closure of the post-closure ash basin area and 1960 Fill Area provided environmental investigation results facilitate MNA as a remedy

### 6.3.1 Physical Closure

Under this scenario, ash and impacted soils from the ash basin and the 1960 Fill Area would be moved to the lined on-site ash landfill and capped with an engineered cover system designed to

isolate and stabilize the ash within the landfill while providing a physical barrier to the environment.

The quantities of ash and impacted soil to be moved to the proposed on-site ash landfill and the quantity of clean cover soil required for cap construction were estimated and are provided in **Table 9**. Estimates of cut and fill required for landfill construction cannot be provided until a hydrogeological investigation is performed at the proposed ash landfill site. For cover soil estimation purposes, the footprint of the on-site landfill was assumed to be 50 acres. Unless specifically noted, the quantities are in-place (i.e., bank measure) quantities that do not include swell or shrinkage factors.

### 6.3.2 Environmental Closure

In this option, ash and impacted soil beneath the ash will be moved to the lined on-site landfill. As such, the environmental closure then becomes more focused on long-term groundwater quality in the vicinity of the former ash basin. Once CoC are established for groundwater within and beneath the ash basin, groundwater fate and transport modeling can be conducted to:

- Predict concentrations of CoC at the facility's compliance boundary or other locations of interest over time;
- Estimate the groundwater flow and loading to surface water discharge areas; and
- Support the development of a corrective action plan, if required.

## 6.4 Off-Site Landfill Ash Basin Closure Option

Under this option, ash and impacted soil from the ash basin and the 1960 Fill Area will be re-located to the off-site lined ash landfill which would be closed with an engineered cap system to reduce infiltration through the ash and underlying materials thereby limiting potential for future migration of CoC. Regrading of the ash basin and 1960 Fill Area would be required after ash and impacted soil removal to ensure that positive drainage is maintained to eliminate ponding and to ensure the final surface can be maintained without excessive erosion. Soil from the decommissioned dam embankment could be used for final grading. Topsoil would also be placed over all regraded areas to encourage the growth of vegetation. Fast-growing vegetative cover consisting of native grasses would initially be established to stabilize the excavated and regraded areas against erosion. Eventually, trees and/or shrubs would be planted or allowed to naturally populate these areas to reduce maintenance requirements.

Removal of ash and impacted soils from the ash basin and 1960 Fill Area and placement within an off-site lined ash landfill would be considered as a closure option if the hybrid close-in-place and on-site ash landfill options discussed in Sections 6 and 7, respectively, are determined to be unfeasible. Development of an off-site ash landfill could be pursued either directly by Duke Energy or through an agreement with a private contractor.

The off-site landfill ash basin closure option would consist of the following:

- Identify potential landfill sites within a reasonable haul distance from the Robinson Plant;

- Rank potential landfill sites according to such factors as location, accessibility, cost and ability to be permitted (e.g. presence of wetlands, threatened and endangered species, historic or archeological sites);
- Purchase or obtain options for highest ranking property and perform site suitability study including geotechnical and hydrogeological exploration;
- Complete permitting of site through SCDHEC;
- Construct a lined ash landfill with leachate collection system at site;
- Consolidate ash and impacted soils from the ash basin and 1960 Fill Area by transporting material to the off-site ash landfill;
- Construct an engineered cover system (soil-geosynthetic) over the ash landfill;
- Establish a groundwater detection monitoring program for the ash landfill;
- Decommission the ash basin and dam embankment from the SCDHEC Dams and Reservoirs Safety Program jurisdiction;
- Establish vegetation within the post-closure ash basin area and 1960 Fill Area; and,
- Evaluate monitored natural attenuation (MNA) for environmental closure of the post-closure ash basin area and 1960 Fill Area provided environmental investigation results facilitate MNA as a remedy.

An alternative to developing a new off-site ash landfill would be to identify an existing landfill within a reasonable haul distance from the Robinson Plant that is permitted to accept coal ash and impacted soil. Such a facility would streamline the permitting process and would probably decrease the amount of time required to achieve physical closure of the ash basin and 1960 Fill Area.

### 6.4.1 Physical Closure

Under this scenario, ash and impacted soils from the ash basin and the 1960 Fill Area would be moved to an off-site ash landfill and capped with an engineered cover system designed to isolate and stabilize the ash within the landfill while providing a physical barrier to the environment.

The quantities of ash and impacted soil to be moved to the proposed off-site ash landfill and the quantity of clean cover soil required for cap construction were estimated and are provided in **Table 9**. Estimates of cut and fill required for landfill construction cannot be provided until a hydrogeological investigation is performed at the proposed ash landfill site. For cover soil estimation purposes, the footprint of the off-site landfill was assumed to be 50 acres. Unless specifically noted, the quantities are in-place (i.e., bank measure) quantities that do not include swell or shrinkage factors.

### 6.4.2 Environmental Closure

Similar to the on-site landfill option, environmental closure for this option is focused on long-term groundwater quality in the vicinity of the former ash basin. Once CoC are established for groundwater within and beneath the ash basin, groundwater fate and transport modeling can be conducted to:

- Predict concentrations of CoC at the facility's compliance boundary or other locations of interest over time;
- Estimate the groundwater flow and loading to surface water discharge areas; and
- Support the development of a corrective action plan, if required.

# 7.0 Schedule

As noted in Section 5.0, collection and evaluation of additional data is necessary to fully characterize subsurface conditions, refine the SCM, and predict groundwater flow and quality conditions over time via groundwater modeling. Duke Energy proposes to collect and analyze these data in accordance with the following schedule.

| Task | Estimated Duration | Estimated Completion Date |
|---|---|---|
| **Winter Seasonal Groundwater Sampling** | 14 days | February 27, 2015 |
| **Spring Seasonal Groundwater Sampling** | 14 days | May 29, 2015 |
| **Summer Seasonal Groundwater Sampling** | 14 days | August 28, 2015 |
| **Groundwater Modeling** | ongoing | September 25, 2015 |
| **Supplemental Conceptual Closure Plan Submittal to SCDHEC** | 60 days | November 20, 2015 |

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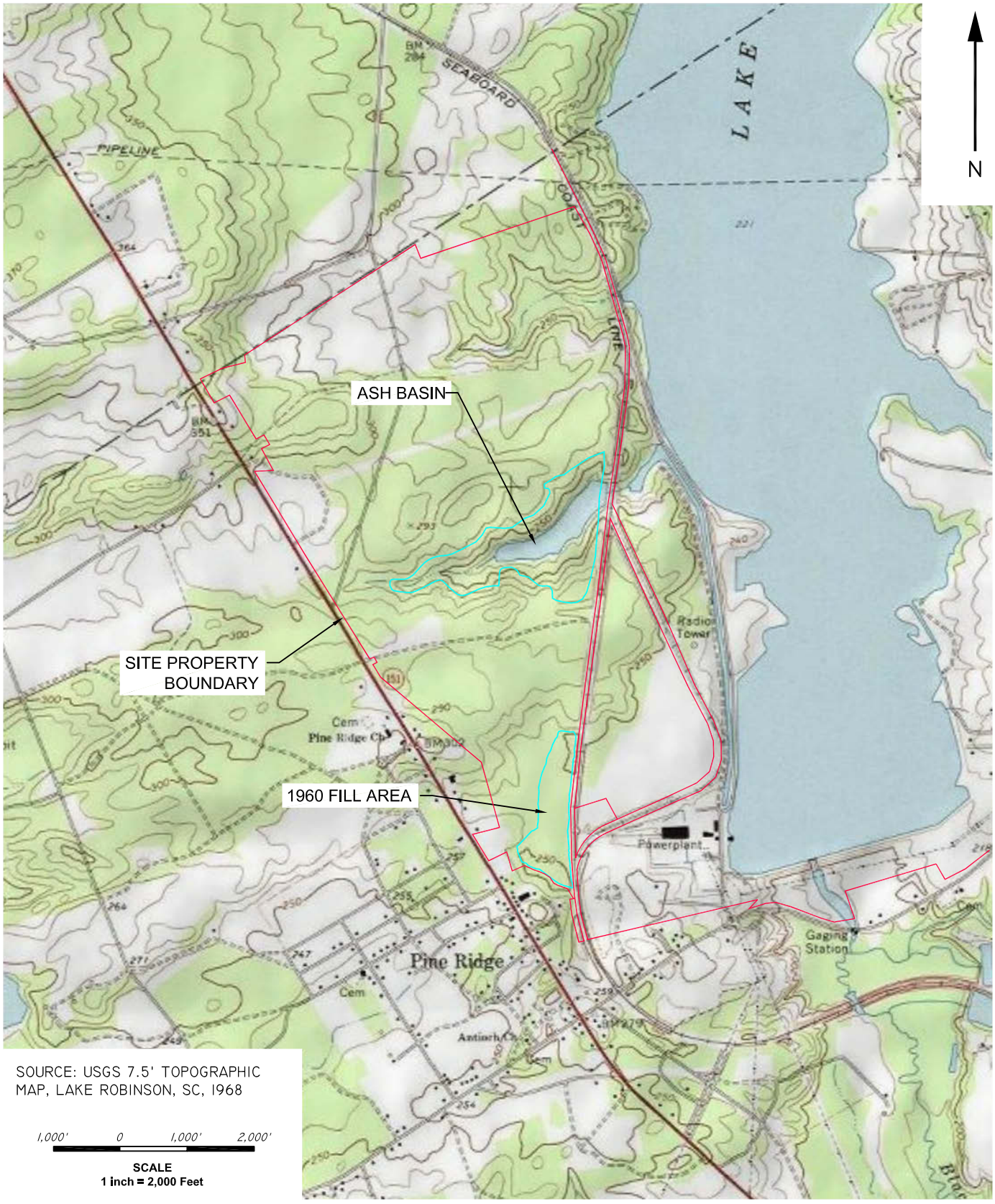
# Figures




SITE LOCATION MAP
H.B. ROBINSON STEAM ELECTRIC PLANT
DUKE ENERGY PROGRESS
DARLINGTON COUNTY, SOUTH CAROLINA

DATE
DECEMBER 17, 2014

FIGURE
1


SCALE (FEET)
300' 0 300' 600'
1" = 600'

North Carolina Engineering Firm Number: F-0116
440 South Church Street Charlotte, NC 28202

SITE LAYOUT MAP
ASH BASIN CLOSURE
DUKE ENERGY PROGRESS
ROBINSON PLANT - ASH BASIN CLOSURE PROJECT
DARLINGTON COUNTY, SOUTH CAROLINA

DATE
12/10/2014

FIGURE
2


SCALE (FEET)
200' 0 200' 400'
1" = 400'

North Carolina Engineering Firm Number F-0116
440 South Church Street Charlotte, NC 28202

MONITORING WELL AND BORING LOCATION MAP
ASH BASIN CLOSURE (ASH BASIN)
DUKE ENERGY PROGRESS
ROBINSON PLANT - ASH BASIN CLOSURE PROJECT
DARLINGTON COUNTY, SOUTH CAROLINA

DATE
12/17/2014

FIGURE
3


SCALE (FEET)
200' 0 200' 400'
1" = 400'

North Carolina Engineering Firm Number: F-0116
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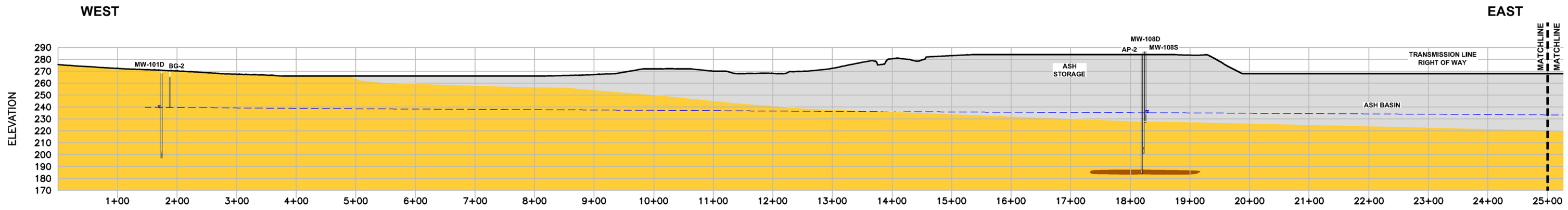
WELL AND BORING LOCATION MAP
ASH BASIN CLOSURE (1960 FILL AREA)
DUKE ENERGY PROGRESS
ROBINSON PLANT - ASH BASIN CLOSURE PROJECT
DARLINGTON COUNTY, SOUTH CAROLINA

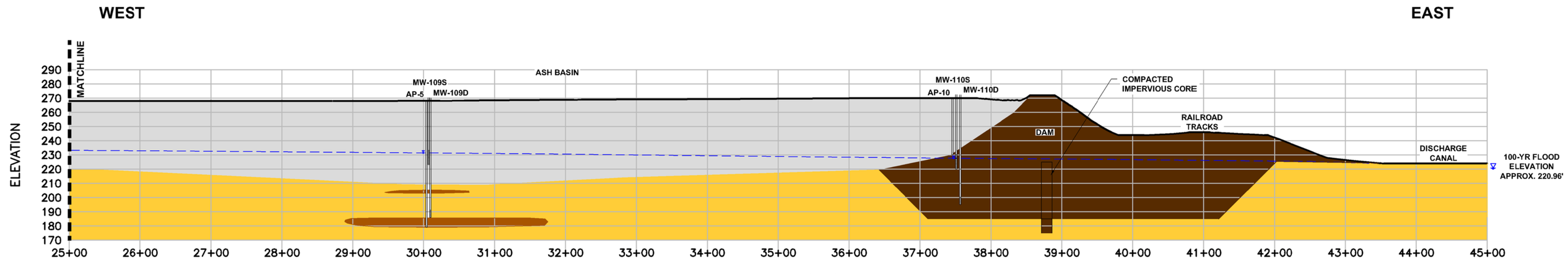
DATE
12/17/2014

FIGURE
4




## SECTION A–A' (1 of 2)

HORIZONTAL: 1"=100'; VERTICAL: 1"=50'




## SECTION A–A' (2 of 2)

HORIZONTAL: 1"=100'; VERTICAL: 1"=50'

LEGEND:

- EXISTING LAND SURFACE
- WATER TABLE SURFACE (ESTIMATED)
- ASH
- FILL
- UNCONSOLIDATED SEDIMENTS
- DISCONTINUOUS CLAY LENS

NOTES:

1. SEE FIGURE 3 FOR CROSS SECTION LOCATIONS.
2. EXISTING LAND SURFACE BASED ON TOPOGRAPHIC SURVEY PERFORMED BY WSP IN JULY 20 14.
3. LITHOLOGY SHOWN IS ESTIMATED BASED ON BORING DATA OBTAINED DURING THE JULY AND AUGUST 2014 CLOSURE INVESTIGATIO N ACTIVITIES.
4. WATER TABLE SURFACE SHOWN IS APPROXIMATEAND BASED ON MONITORING WELL WATER ELEVATIONS MEASURED ON NOVEMBER 17, 2014.

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Charlotte, NC 28202-2075
704.338.6700

| ISSUE | DATE | DESCRIPTION |
|---|---|---|
| A | 12/2014 | ISSUE FOR APPROVAL |

| | |
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| PROJECT MANAGER | M. FILARDI, P.G. |
| PROJECT ENGINEER | |
| STRUCTURAL | |
| PLUMBING | |
| ELECTRICAL | |
| DRAWN BY | C. HEARN, P.E. |
| PROJECT NUMBER | 011237-243758-.012 |

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Duke Energy Progress

Robinson Plant
Ash Basin Closure Project

DARLINGTON COUNTY SOUTH CAROLINA

**CROSS SECTION A-A'**

0 1" 2"

FILENAME 01C-04.DWG
SCALE AS SHOWN

SHEET
**FIGURE 5**

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SCALE (FEET)
200' 0 200' 400'
1" = 400'

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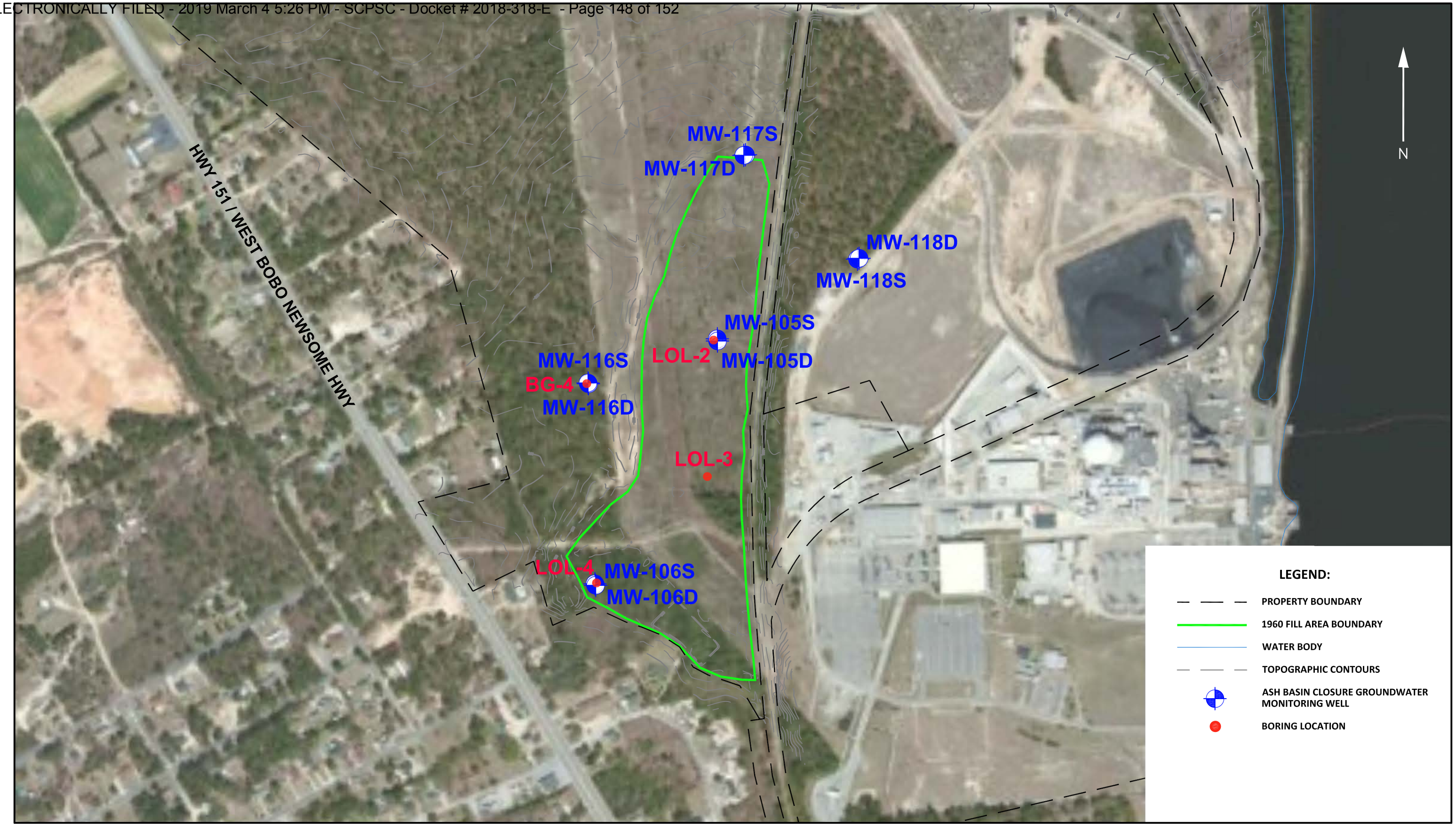
440 South Church Street Charlotte, NC 28202

MONITORING WELL AND BORING LOCATION MAP
ASH BASIN CLOSURE (ASH BASIN)
DUKE ENERGY PROGRESS
ROBINSON PLANT - ASH BASIN CLOSURE PROJECT
DARLINGTON COUNTY, SOUTH CAROLINA

DATE 12/17/2014

FIGURE 3




SCALE (FEET)
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1" = 400'

North Carolina Engineering Firm Number: F-0116
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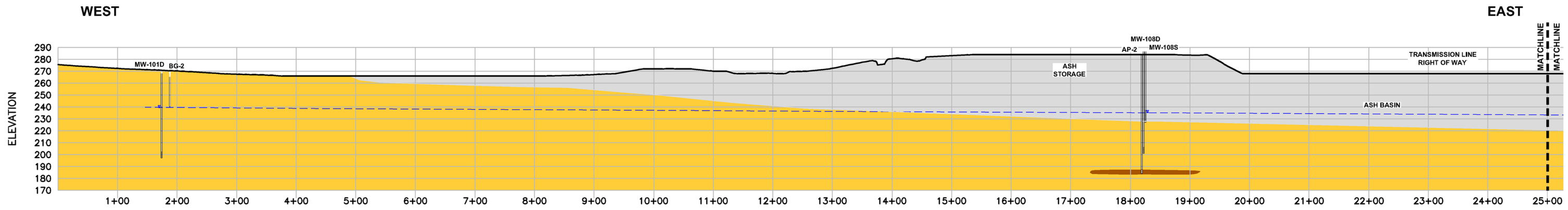
WELL AND BORING LOCATION MAP
ASH BASIN CLOSURE (1960 FILL AREA)
DUKE ENERGY PROGRESS
ROBINSON PLANT - ASH BASIN CLOSURE PROJECT
DARLINGTON COUNTY, SOUTH CAROLINA

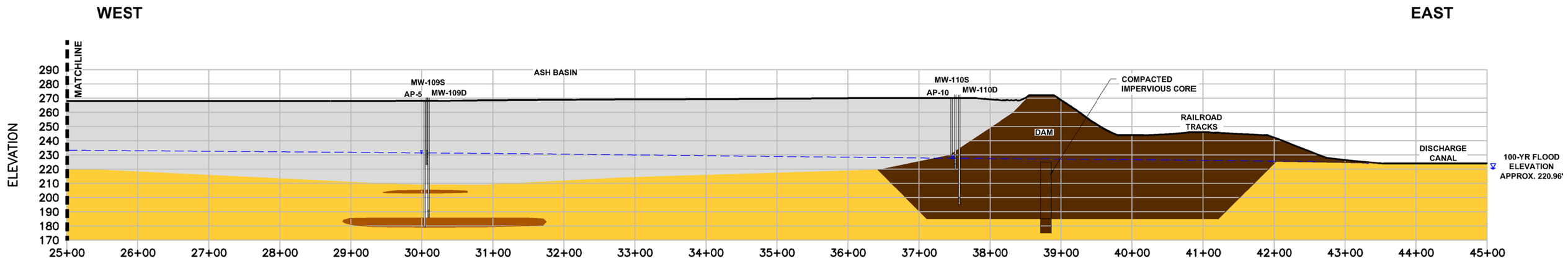
DATE
12/17/2014

FIGURE
4




## SECTION A–A' (1 of 2)

HORIZONTAL: 1"=100'; VERTICAL: 1"=50'




## SECTION A–A' (2 of 2)

HORIZONTAL: 1"=100'; VERTICAL: 1"=50'

LEGEND:

- EXISTING LAND SURFACE
- WATER TABLE SURFACE (ESTIMATED)
- ASH
- FILL
- UNCONSOLIDATED SEDIMENTS
- DISCONTINUOUS CLAY LENS

NOTES:

1. SEE FIGURE 3 FOR CROSS SECTION LOCATIONS.
2. EXISTING LAND SURFACE BASED ON TOPOGRAPHIC SURVEY PERFORMED BY WSP IN JULY 20 14.
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| PROJECT NUMBER | 011237-243758-.012 |

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**CROSS SECTION A-A'**

0 1" 2"

FILENAME 01C-04.DWG
SCALE AS SHOWN

SHEET
**FIGURE 5**

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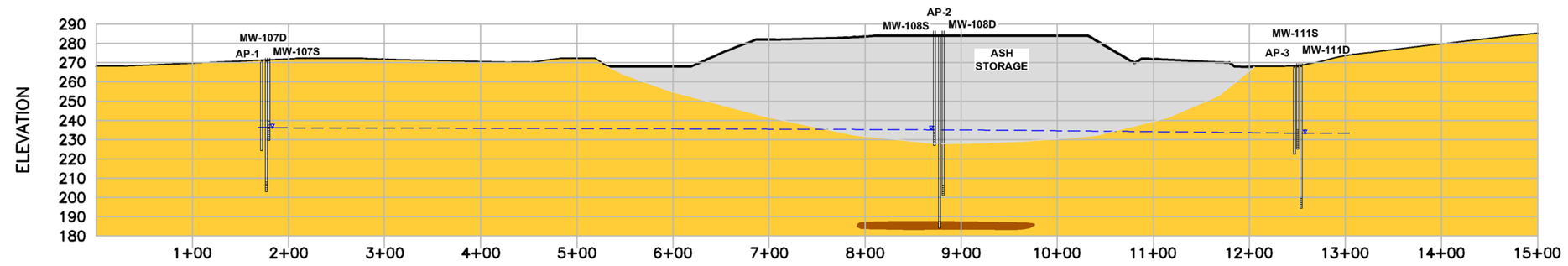


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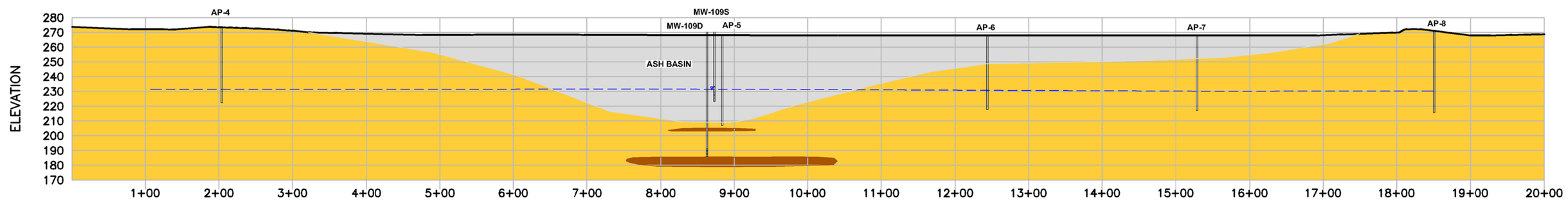


SECTION C–C'

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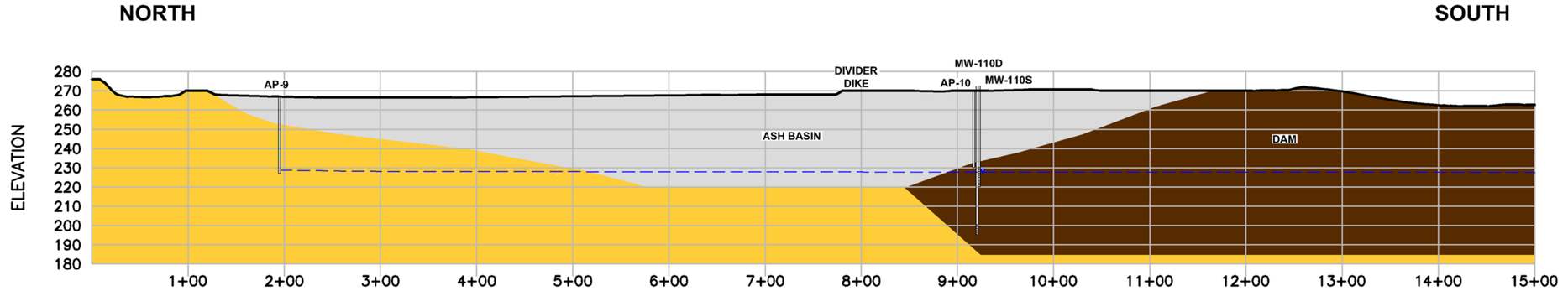


SECTION D–D'

HORIZONTAL: 1"=100'; VERTICAL: 1"=50'

LEGEND:

- EXISTING LAND SURFACE
- WATER TABLE SURFACE (ESTIMATED)
- ASH
- FILL
- UNCONSOLIDATED SEDIMENTS
- DISCONTINUOUS CLAY LENS

NOTES:

1. SEE FIGURE 3 FOR CROSS SECTION LOCATIONS.
2. EXISTING LAND SURFACE BASED ON TOPOGRAPHIC SURVEY PERFORMED BY WSP IN JULY 20 14.
3. LITHOLOGY SHOWN IS ESTIMATED BASED ON BORING DATA OBTAINED DURING THE JULY AND AUGUST 2014 CLOSURE INVESTIGATIO N ACTIVITIES.
4. WATER TABLE SURFACE SHOWN IS APPROXIMATEAND BASED ON MOIITORING WELL WATER ELEVATIONS MEASURED ON NOVEMBER 17, 2014.

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| ELECTRICAL | |
| DRAWN BY | C. HEARN, P.E. |
| PROJECT NUMBER | 011237-243758-.012 |

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Ash Basin Closure Project

DARLINGTON COUNTY SOUTH CAROLINA

**CROSS SECTIONS B-B', C-C' AND D-D'**

0 1" 2"

FILENAME 01C-04.DWG
SCALE AS SHOWN

SHEET
**FIGURE 6**

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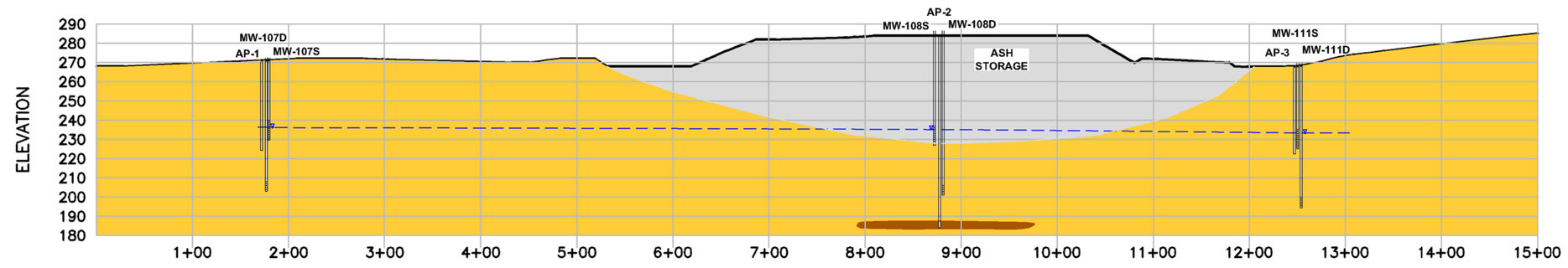
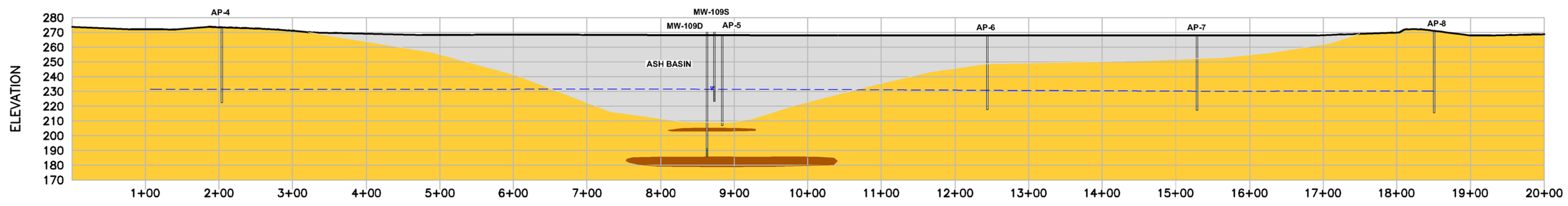


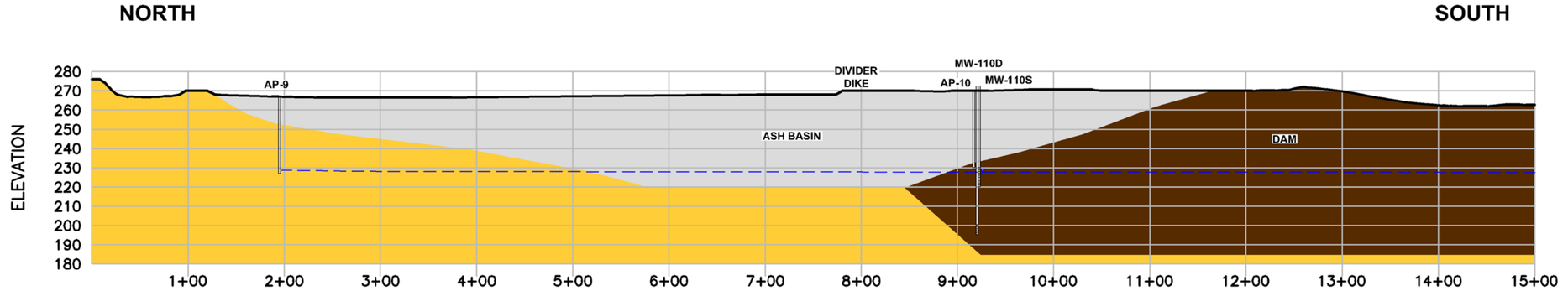

SECTION B–B'

HORIZONTAL: 1"=100'; VERTICAL: 1"=50'




SECTION C–C'

HORIZONTAL: 1"=100'; VERTICAL: 1"=50'




SECTION D–D'

HORIZONTAL: 1"=100'; VERTICAL: 1"=50'

LEGEND:

- EXISTING LAND SURFACE
- WATER TABLE SURFACE (ESTIMATED)
- ASH
- FILL
- UNCONSOLIDATED SEDIMENTS
- DISCONTINUOUS CLAY LENS

NOTES:

1. SEE FIGURE 3 FOR CROSS SECTION LOCATIONS.
2. EXISTING LAND SURFACE BASED ON TOPOGRAPHIC SURVEY PERFORMED BY WSP IN JULY 20 14.
3. LITHOLOGY SHOWN IS ESTIMATED BASED ON BORING DATA OBTAINED DURING THE JULY AND AUGUST 2014 CLOSURE INVESTIGATIO N ACTIVITIES.
4. WATER TABLE SURFACE SHOWN IS APPROXIMATEAND BASED ON MOIIITORING WELL WATER ELEVATIONS MEASURED ON NOVEMBER 17, 2014.

HDR Engineering, Inc. of the Carolinas
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| ISSUE | DATE | DESCRIPTION |
|---|---|---|
| A | 12/2014 | ISSUE FOR APPROVAL |

| | |
|---|---|
| PROJECT MANAGER | M. FILARDI, P.G. |
| PROJECT ENGINEER | |
| STRUCTURAL | |
| PLUMBING | |
| ELECTRICAL | |
| DRAWN BY | C. HEARN, P.E. |
| PROJECT NUMBER | 011237-243758-.012 |

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Duke Energy Progress

Robinson Plant
Ash Basin Closure Project

DARLINGTON COUNTY SOUTH CAROLINA

**CROSS SECTIONS B-B', C-C' AND D-D'**

0 1" 2"

FILENAME 01C-04.DWG
SCALE AS SHOWN

SHEET
**FIGURE 6**

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EXHIBIT DJW - 7.2
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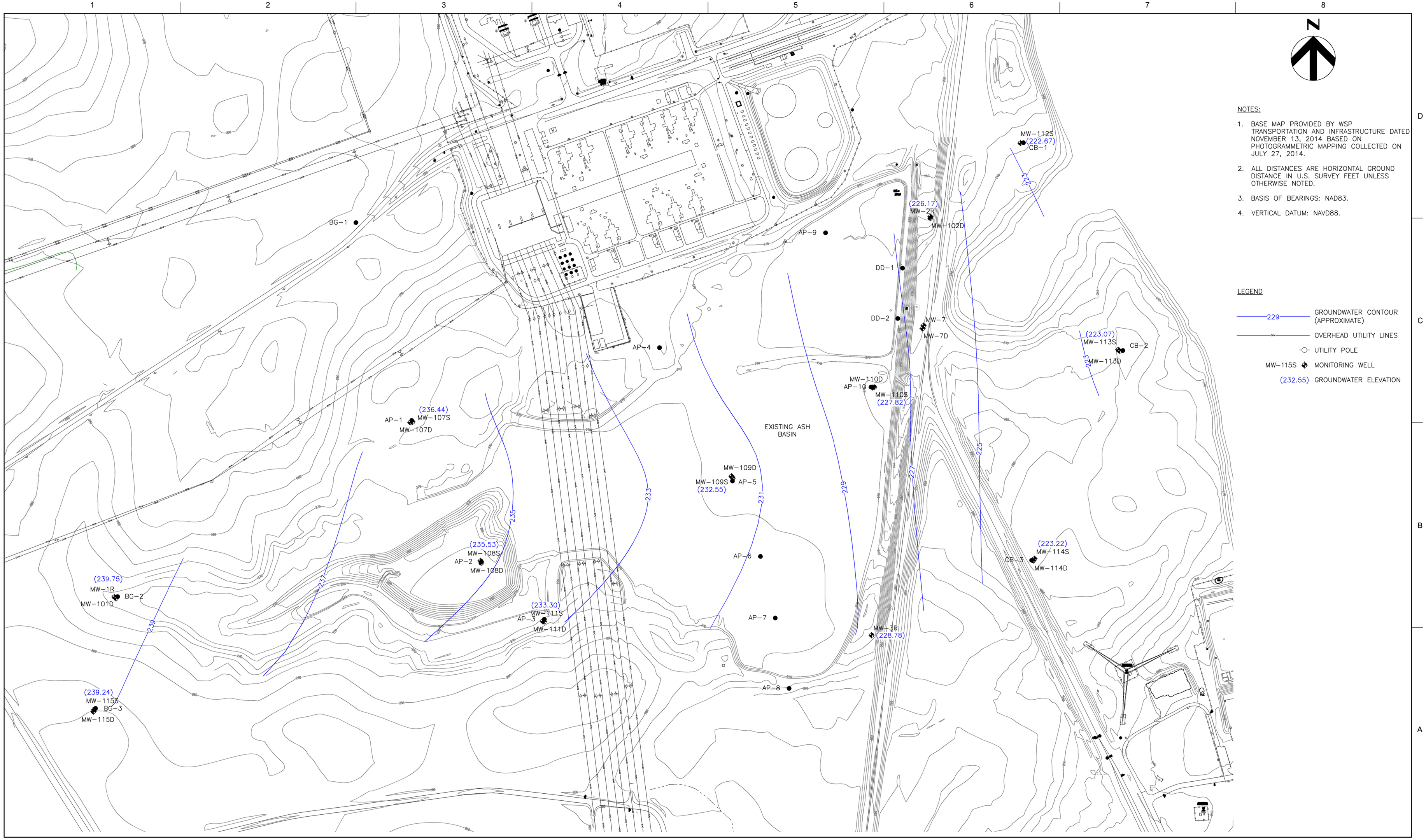


NOTES:

1. BASE MAP PROVIDED BY WSP TRANSPORTATION AND INFRASTRUCTURE DATED NOVEMBER 13, 2014 BASED ON PHOTOGRAMMETRIC MAPPING COLLECTED ON JULY 27, 2014.
2. ALL DISTANCES ARE HORIZONTAL GROUND DISTANCE IN U.S. SURVEY FEET UNLESS OTHERWISE NOTED.
3. BASIS OF BEARINGS: NAD83.
4. VERTICAL DATUM: NAVD88.

LEGEND

- 229 — GROUNDWATER CONTOUR (APPROXIMATE)
- OVERHEAD UTILITY LINES
- UTILITY POLE
- MW-115S — MONITORING WELL
- (232.55) GROUNDWATER ELEVATION

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# Duke Energy Progress

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## POTENTIOMETRIC SURFACE MAP ASH BASIN NOVEMBER 17, 2014

0 1" 2"

FILENAME 01C-03.dwg
SCALE 1" = 200'

SHEET
**FIGURE 7**

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